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JULY, 1920

LETTER OF TRANSMITTAL

To Hon. Albert E. Sleeper, *Governor of the State of Michigan:*

Sir—I have the honor to submit herewith the XXI Annual Report of the Michigan Academy of Science for publication, in accordance with Section 14 of Act No. 44 of the Public Acts of the Legislature of 1899.

Respectfully,

I. D. SCOTT,

Secretary.

Ann Arbor, Michigan, June, 1919.

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Prof. LeRoy H. Harvey, Kalamazoo.

Prof. Frank T. Carlton, Albion.

TWENTY-FOURTH ANNUAL MEETING

OF THE

MICHIGAN ACADEMY OF SCIENCE

ANN ARBOR, MICHIGAN

April 3 and 4, 1919

GENERAL PROGRAM.

THURSDAY, APRIL 3.

10:00 a. m. Meeting of the Section of Economics, Lecture Room, Second Floor, Economics Building.

12:00 m. Luncheon for members of Section of Economics, Michigan Union.

2:00 p. m., sharp. Council meeting, Room Z 231, Natural Science Building. Reports of committees. Nominations for membership.

2:30 p. m. General meeting of the Academy, Room B 207, Natural Science Building. Reports of committees. Election of members.

3:00 p. m. Meetings of the following Sections:

Agriculture—Room G 437, Natural Science Building.
Botany—Room B 207, Natural Science Building.
Economics—Lecture Room, Second Floor, Economics Building.
Geology and Geography—Room G, 321, Natural Science Building.
Psychology—Room P 162, Natural Science Building.
Sanitary and Medical Science—Room 319, Medical Building.
Zoology—Room Z 355, Natural Science Building.

8:00 p. m. Presidential Address, by Professor Frank T. Carlton: *"The Human Element in Industry."* Auditorium, Natural Science Building. This lecture is open to the public.

9:00 p. m. Smoker given by the Research Club to members of the Academy in the University Club rooms, Alumni Building.

FRIDAY, APRIL 4.

8:30 a. m. Council meeting.

9:00 a. m. Meetings of Sections for the reading of papers* and the nomination of Vice-Presidents and Editors.

10:00 a. m. Meeting of Section of Economics.

12:00 m. Luncheon for Biologists.

1:30 p. m. General meeting of the Academy. Election of officers and members.

2:00 p. m. Meeting of Section of Economics.

8:00 p. m. Public Address, by Gerald H. Thayer, *"Camouflage in War and Nature,"* Hill Auditorium. This lecture is open to the public.

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*The papers presented at the sectional meetings are listed under Papers Presented on page 6.

ADDRESS OF THE PRESIDENT OF THE MICHIGAN ACADEMY OF SCIENCE.

DELIVERED THURSDAY, APRIL 3, 1919.
AUDITORIUM, NATURAL SCIENCE BUILDING.

THE HUMAN ELEMENT IN INDUSTRY.

FRANK T. CARLTON.

Industry may be studied from the technical or non-human side or from the human side. Industrial experts have devoted much attention to the study of materials and machines, but unfortunately until quite recently only a minimum amount of attention has been directed to investigation of the most important factor in production,—men and women. In the words of another, "man is on the way to master inanimate things, but hitherto the failure has been in treating human beings too much like things." Wage workers have been treated as machines, as hands, as "factory fodder." Without exaggeration, it may be asserted that one of the most important, if not the greatest, economic problems of today is that of releasing effectively and efficiently, the productive energy of human beings and of groups of human beings. Few individuals work up to their possibilities and rarely are groups of individuals properly and harmoniously coordinated for the most effective results. Factories are filled with wage workers, but what is needed is an efficient and eager working force. There is too much latent talent and energy in the mass of breadwinners which rarely is utilized in productive industry. Our participation in the World War partially revealed America's "tremendous industrial capacity."

The goal of progress in the industrial sphere is twofold:—(1) Increased production at diminishing expense, and (2) increasing satisfaction on the part of workers in their work. Work as well as leisure should offer opportunities for self-expression and enjoyment on the part of the rank and file of workers. The United States sorely needs more training for the sort of efficiency which is not merely predatory, for the fine and rare variety which makes for industrial harmony and social well-being. We should have more careful consideration of desirable modifications in the old and accepted forms of control in industry. It is the purpose of this paper briefly to discuss two steps which it is urged should be taken in order to raise the level of efficiency in American industry and to insure industrial peace. (1) Greater emphasis should be placed upon the development of individuality in industry. (2) Industrial autocracy should be replaced by some form of industrial democracy or constitutionalism. It is held also that the first cannot be taken without the second.

Many of the fundamental concepts of American democracy may be traced back to the pioneers of the days of Jackson and William Henry Harrison; and Americans are quite inclined to believe that industry until recent years has ever taken the form of the small-scale business of the period from 1800-1850. We are disappointed if the workers of today do not display the same interest in their work as did the pioneer farmer or the small-shop craftsman when working for himself. The employer and the man-on-the-corner today expect the carefully directed worker, deprived of all opportunity for initiative, self-assertion or responsibility, doing a certain simple task over and over again, to exhibit the interest and zeal which is traditionally ascribed to the pioneer American. The common mode of procedure has been vigorously to denounce the worker of today, especially if he be a member of a labor organization. Few have stopped to inquire:—Why are conditions as they are? What steps will insure betterment?

But, with certain exceptions such as are presented by the gildsmen of Western Europe and by the American pioneers who virtually employed themselves, history discloses that from the early days when the captives in battle were forced to till the soil for the benefit of their conquerors, through the long hopeless ages of slavery and serfdom, to the modern wage system with its definite contractual payment of money wages, the great mass of the world's workers have been dragged unwillingly into productive activity. Compulsion—the fear of the lash, of discharge, of hunger and of the lack of comforts—has been the potent, but negative, force which has throughout the ages hastened the steps of the lagging worker. This negative incentive has not and cannot make for efficiency, for joyful and creative work. Coercion will not produce good work; it is first necessary "to produce desire in the heart of the workman to do good work." "Man's place in industry is not to be mastered but to provide free and willing service."

Even today according to critics of the present industrial situation, "the whole industrial arrangement is carried on without the force of productive intention; it is carried forward against a disinclination to produce"; and a disinclination to produce will inevitably breed unreliability and inefficiency. Consequently, the present industrial arrangement in common with the earlier forms known as slavery and serfdom, must be inefficient from the standpoint of output, and also deadening and debilitating in its effect upon the individual workers. In this connection it may also be pointed out that the growth of the corporate form of business and the tendency to interpose "layers of corporate securities" between the owners and the property actually owned, tends to destroy the "pride of ownership" and the "joy of workmanship" which the owner so often exhibited in the days when smaller-scale and more simple industrial enterprises were the rule. The typical owner of corporate securities is an investor or a speculator rather than a person interested in the

technical processes of production. The tendency toward routine, toward scientific management, and toward centralized and depersonalized supervision in modern large-scale industry is making "individuality in industry" a rare phenomenon.

The negative incentives furnished by compulsion are not only inefficient now as was also true in the days of slavery and of serfdom, but, in an era of democracy and of compulsory education for all classes, unless re-enforced and modified by others of a more inspiring and stimulating type, the negative incentives provide social dynamite which will sooner or later put civilization in the imminent danger of a serious social upheaval.

The complex of instincts, habits, passions, prejudices, likes and aversions called man is the slowly and painfully evolved product of unnumbered generations. Man is the resultant of generations in which there was little of routine, regularity or reasoning. Man is endowed with almost ineradicable instincts and impulses which are the fruits of environmental conditions in the ages past. Modern industry on the contrary is a recent and artificial contrivance; it is the gift of the last two or three generations. The man who has become a cog in the gigantic articulated modern tread-mill is subjected to experiences and influences which cut across, thwart and inhibit many of the impulses and keen desires which he has inherited from the long ago.

The problem of the social sciences—if they have any adequate grounds for demanding the appelation of sciences—is to hasten the adjustment of associated men to the conditions of modern life and to reduce the friction accompanying such adjustment. To accomplish this purpose evidently both the environmental conditions and the psychology of human beings must be carefully investigated. There is reason for believing that the fundamental impulses and instincts of mankind have changed little since the primitive man appeared.

According to McDougal, "men are moved by a variety of impulses whose nature has been determined through long ages of evolutionary process without reference to the life of man in civilized society." Such being the case, our problem becomes one of finding out what these fundamental impulses, instincts and emotions are, and to find expression for them in ways which make for uplift and racial betterment. Repression inevitably spells danger. It is quite clear that the instincts which long racial experience have evaluated as essential to survival cannot be easily swept aside by a few generations of regular industry, relative peace and plenty. We must reckon with them. To continue to disregard them is to close the door upon the possibility of making economics or sociology scientific. Assuming that human nature is not plastic or easy to modify, the most practical solution of the problem of industrial efficiency may be judged to lie in a definite and planned attempt to modify

industrial conditions so as to offer as far as possible an outlet for the underlying impulses of mankind.

Heretofore, economists and other social scientists have been prone to consider men—workingmen at least—to be single-track individuals,—persons of few and fairly simple guiding instincts and impulses. We have built up a sort of straw man, and then proceeded with calmness to argue on the basis of this artificial, air-castle-like development of our own making. Students of American industrial problems have rarely stopped to study the actual, flesh-and-blood man and his motives. We have paid little attention to the problem of adapting industry and environment to men. We have naively accepted the crude idea that the great mass of people must fit into the new industrial environment even though it be quite dissimilar to that of preceding ages,—the ages in which the type of man was molded and cast. It was a maxim of Catherine II of Russia that a ruler operates on human skin which is exceptionally ticklish. The same proposition holds in regard to direction and control in the industrial field. It is a ticklish proposition in which the wants, prejudices, preconceived notions, ambitions and instincts of human beings cannot be disregarded with impunity.

For example, is industrial inefficiency and restriction of output due to the lack of potent incentives which touch the rank and file of industrial workers? Upon the correct answer to this question depends the possibility of formulating worth-while plans for industrial improvement. The late Professor Parker declared that laziness, in so far as it exists, is "an artificial habit, inculcated by civilization." The slacker in industry is produced by "the job and the industrial environment." Students of child life are practically agreed that the normal healthy child is neither lazy or bad. The artificial environment which adults ignorantly or selfishly provide, often makes him appear to be so. The normal adult is only the youth overlaid with custom, precepts, inhibitions and experiences.

On the other hand, a recent writer who is a student of psychology quite emphatically asserts that "peoples and individuals are by nature indolent." And, certainly unless prodded by opposition, rivalry, changed environmental conditions, unsatisfied wants or some other potent incentives, human beings tend to settle down comfortably into ruts, amiably to let well enough alone, and to be satisfied with much less than their best or near-best. The normal individual may not be lazy in the sense of desiring merely to loaf; but he does not love the routine of present-day industry as a regular day-after-day, year-in-and-year-out process from which the only tangible result from his point of view is a meager living for himself and family accompanied by extreme weariness of the flesh. Normal men may indeed possess an imperious instinct of workmanship or contrivance; but the up-to-date factory practicing minute subdivision of labor is equipped with excellent means of inhibiting this instinct.

Undoubtedly, a worker may become so inured to routine that he will feel uncomfortable when out of the traces of his daily occupation; but such is an acquired feeling. It does not make for the zest and interest which lead men to push joyously ahead to newer planes of achievement.

The two points of view discussed above are not necessarily contradictory. Normal human beings are so constituted as to enjoy activity which makes for worth-while results. What is considered to be worth-while obviously changes with time, place and kind of civilization. But, the normal active, non-lazy individual placed in an environment chiefly characterized by monotony and the lack of incentives for improvement or change, will after a time accept the present achievements as sufficient and follow the daily routine without enthusiasm. Certain vigorous and recalcitrant persons will rebel and try to escape from the hum-drum and correctness of the place and period; these are the heretics, the radicals, the I. W. W.'s.

One of our able and successful business managers out of his experience has put the matter very clearly. "The desire for self-expression is one of the most fundamental instincts in human nature, and unless it is satisfied it is bound to manifest itself in all sorts of abnormal ways which today are working such havoc in society." The late John E. Williams testified before the Commission on Industrial Relations that "the I. W. W.'s would not be very different from the other people if they had the proper organ of expression. It is just that sense of futility of their lot, of their means of action, that makes people resort to these measures of force." The last sentence is worthy of more than passing notice; it presents a vital fact from a man of much practical experience. Unfortunately, industry is offering little opportunity for self-expression to the average worker; it does not stimulate the interest of the worker in his work. In the use of potent incentives, modern large-scale routine industry has progressed little beyond slavery and serfdom.

It is too much to expect men to act conservatively and according to the customary procedure when they have little or no opportunity for the normal expression of human wants and desires. If they are unable to satisfy the instinct for food or for self-assertion, they will inevitably become biased, gnarled, knotted and perverse individuals. To make them more like the well-to-do conservative, the unblessed must be made more well-to-do. The much-abused and much-feared I. W. W. is composed largely of men whose instincts for family life, for acquisition of wealth, for contrivance or workmanship, and for self-assertion have been inhibited. Better treatment, better wages, opportunity in youth to acquire a little property are solvents for extreme radicalism.

Psychologists point out that changed environments have frequently changed individuals in an extraordinary manner,—from ne'er-do-wells to leaders, from criminality to useful citizenship, from sluggishness to a condition

[1]Swift, Psychology and the Day's Work, pp. 28-29.

of mental alertness. A change in industrial methods, in the workshop conditions, in the incentives to activity may likewise work marvelous changes in the activities and the attitude of workers. "Primitive man, like his animal ancestors, expended tremendous strength and, having won his fight, relapsed into inaction, revelling in the fruits of victory."[1] The man in the factory, the mine or the store is capable of extraordinary activity on occasion,—note his activity when witnessing a close base-ball game, when on a strike or in case of an emergency such as a fire. The vocation of the mass of wage workers today offers very little to fire the workers or to arouse their latent energy or talents; there are few or no episodes which stir the blood and call for temporary, excessive or invigorating expenditure of effort. As a consequence the average worker soon exhibits the all too familiar "tendency to minimum effort." In modern industry, except for a small group, "improvement stimulus" is practically lacking. The great mass of unstimulated workers become uninterested and inefficient workers; they do not feel those incentives which stir human beings into activity. Yet, business competition can be made to offer opportunities for potent stimuli. One force, group or gang may become interested in its performance as compared with that of another or with its preceding performance. But, unless the workers have some very definite voice in determining the conditions of rivalry, in sharing in its benefits, it is presently looked upon as a scheme on the part of the employer to increase profits,—and too often with excellent reasons for such conclusion.

The situation in American industry—a skilled staff of mental workers and a mass of routine workers without any voice in the management of the industry in which they work—runs directly counter to the ideals of American political democracy and to the fundamental principles upon which the American public school rests. The schools of Germany "were organized upon the servility of the people"; but those of the United States on the ideal of individual initiative and equality of opportunity. Unfortunately, in this country industry and, too frequently, the school as well are destroying the plasticity, the initiative and the self-reliance of the youth; and the much-lauded systems of scientific management seem to constitute a further step in the same direction.

The effect of routine in industry is to divide the army of unskilled and semi-skilled workers in this country into two classes: (1) those who are becoming more and more lethargic, and (2) those who rebel against the autocracy of business and the monotony of the work thus augmenting the ranks of the migratory workers. The trend in industry is to reduce the relative demand for skilled men and to add to the relative number of unskilled workers. The future of the workers in the occupations requiring little skill is, consequently, becoming of increasing significance. The great mass of laborers have little opportunity for self-expression, self-assertion and self-direction.

They are in too many workplaces servile, driven, cowed. These conditions do not make for efficient workmanship or for good citizenship. Docile and mechanized workers cannot be as efficient, their per capita output will be less than that of workers who take an interest in their work, who have an opportunity to do creative work, and who have some even though it be small, voice in the management of the business. The laborer may be made to work; but the unwilling worker is below the par of efficiency. Every teacher knows that the uninterested pupil does not measure up to his possibilities; it is not as well understood that the uninterested wage worker is the inefficient and careless worker. Moreover, such a situation may easily develop the combustible stuff out of which is formed the personnel of the I. W. W. or of the Bolsheviki. Out of the regimentation of docile individuals into well-disciplined groups of zestless individuals grows the danger of sudden and violent self-assertion.

The thwarting of the instinctive desires among working people tends as in the case of school children, to produce unrest, abnormality, delinquency and, in some cases, violence. Workers, thwarted by industrial conditions, become abnormal men and women. Keen observers have noted the growth of "sullen hostility" toward the employing class on the part of the migratory workers. The great group of migratory or nomadic workers have lost the incentives and the point of view which places emphasis upon workman-like qualities. They are drifting and rootless workers who are hostile to employers, to organized society and to the ideals which the middle class and the more conservative type of workmen blessed with home ties and a stake in life, hold dear. The problem is not one of statics or of going back to a pre-war footing; it is rather one of movement toward industrial democracy of the type advocated by the British Labor Party or toward syndicalism and I. W. W.-ism. The urgent problem is to find a practical middle ground in industry between autocracy or Prussianism and syndicalism or Bolshevism.

Programs for reconstruction or re-adjustment should be formulated with this situation in mind. The reactionaries of today are playing into the hands of the syndicalists and ultra-radicals. Punishment alone is insufficient in dealing with criminals; and it will likewise prove insufficient in dealing with the radical members of the I. W. W. The United States should give them an opportunity to earn an honest livelihood, to gain a semblance to equality of economic opportunity, and to satisfy the fundamental and deep-seated instincts of human nature such as self-assertion, acquisitiveness and contrivance. If we are not ready to take this step toward making this country safe for democracy, let us again read the records of historic political and social upheavals.

The ideals of the American educational system—though very imperfectly carried out in actual practice—call for the development of thinking and self-

reliant individuals. For the rank and file, industry has been putting a premium upon docility and the absence of thinking or contriving. Why ask our public schools to train the great mass of workers, if the latter are to become semi-automatic human machines? In fact, such training aids in increasing unrest and discontent. The remedy, however, is not retrogression in regard to education. The remedy for many of the social and industrial ills of today is to be found in greater individualization in the work-shop, in greater stimulation of the spirit of initiative and self-reliance, and in a growing interest in the quality of output, among the great drab mass of wage workers. How can this remedy be applied?

The problem is: Can routine, sub-divided industry be made interesting? Can the "creative impulse" be given play? Can the "adventure of business" be opened up to the wage workers? Or, must plans for betterment be directed solely or, at least in a large measure, toward securing the short working day and such utilization of leisure time as will make for physical, mental and moral uplift? The second alternative is one worthy of promotion; but our present concern is with the former. In fact, if more potent incentives were disclosed in industry, if workers became more interested in their work, if one's work expressed in some degree his individuality, and if the workers were given a share in the responsibility of management, the recreation problem would be less difficult of solution. The remainder of this paper is to be devoted to a brief consideration of the first alternative.

Keeping in mind the considerations which have been presented, let us briefly analyze some of the recent plans for industrial betterment.

1. The much-heralded and much-lauded scientific management has accomplished important results; but has fallen far short of maximum possibilities. Efficiency engineers almost without exception have failed adequately to take into account the human side of the industrial equation. In their neatly prepared programs, the employees are as pawns to be moved at will on the industrial chessboard. The workers are practically shorn of all responsibility. But the road to efficiency in industry and to interest in work and output does not lead toward bureaucratic control. The most vital weakness in scientific management of the typical sort is that it does not lead the workers to take an interest in increasing the output of the shop. I am not arguing that all work can be transformed into pleasurable activity. Quite likely work will remain work, and play continue to be play. But I do not contend that in some measure it is possible to reduce the drudgery which so often accompanies work in modern industry, and that it is possible to make certain kinds of routine work interesting. Further, it is contended that this may be accomplished in part by giving the worker some voice in the planning and administration of industry, by providing a vent for his instinct of contrivance, and by making him feel that his work is worth-while.

2. Welfare work and profit sharing are highly paternalistic and are viewed with suspicion by the rank and file of industrial workers. The workers' point of view is neglected in nearly all plans for welfare work or for profit sharing.

3. A recent and promising step has been taken by certain managers of industrial plants. It is an attempt to introduce individuality into industry, to treat the worker as a self-respecting man capable of taking some responsibility upon his own shoulders. "It is our plan," writes Mr. R. B. Wolfe, "to increase his (the workers) responsibility, and we feel that it is our duty to teach him to exercise reasoning power and intelligence to its fullest extent." A definite attempt is made to enlist the creative spark which is the inheritance of all men, in increasing productivity. The desire to do good work which all men possess is appealed to. The personal touch between management and men is introduced. Bonus schemes and premium plans are little used as incentives. This plan is a long step in the right direction. The greatest weakness in it as an adequate solution of the labor problem is disclosed by pointing out that no provision is apparently made for control by the workers. It is not necessarily a step toward industrial democracy; but it does give some recognition to the psychology of workers.

4. We are, however, witnessing some of the first steps toward industrial democracy. The joint responsibility of management and employees for the quantity and quality of output is being recognized by the new style of scientific management. William Filene's Sons' Company of Boston give their employees organized into the Filene Cooperative Association a voice in managing the business and in shaping the policies of the company. Up to date this company has found its employees to be reasonable and conservative. In January, 1919, the daily press reported that an ice company in Detroit had given a council composed of representatives of its employees a voice in determining the policies of this company. Under war conditions both the Fuel Administration of the federal government and the National Coal Association of coal mine operators favored a long step toward democracy in industrial control in the coal mines. "In each mine we are now appointing a committee of six persons. Three of them represent the management. The other three are chosen from among the rank-and-file employees. In unionized districts these three representatives of the employees will be chosen by action of the union. And for what purpose? Not to discuss wages and profits. Other committees will deal with the division of the spoils of production. These committees are to deal with production itself, with its technique. We shall have union officials charged with a responsibility for getting out more coal. We shall have rank-and-file employees, at the end of each day, apportioning the blame for inadequate output, part of it to such and such failures by the working force, part of it to

such and such failures by the management."[2] In England, various plans have been proposed or adopted which lead toward "constitutionalism in industry."

These and other plans of forward-looking business concerns are innovations; and many hard-headed individuals are ready to sneer and to point out the impossibility of success. It should not be forgotten, however, that every worth-while innovation meets ridicule and opposition. One writer on business affairs puts the matter in a nutshell when he writes: Many managers "don't want to learn new ways." They want to get results in their way. The ways of business managers are too frequently traditional and autocratic. The foundation principles come down from the time of slavery. Little or no attention is paid to the wishes or ideas of the workers. It is assumed by the old-fashioned employer that the average worker is a blockhead and one to be driven. The former puts fear into the breasts of the workers. The possibility of harmonious conferences in regard to grievances and production methods is scouted. The traditions of the American business world regarding the rights of employers and employees and of the relations between managers and men are about to suffer from disturbing influences. A new era is dawning; but just what it will be depends greatly upon the willingness and the ability of leaders in the business world to adjust their policies and to study the situation from other points of view than that of the man "who proposes to run his own business to suit himself." "The job must be made worth while" for the worker, —if efficiency is to follow. The old idea that the essence of the labor problem consisted in keeping laborers contented on wages which were insufficient to live upon, is being replaced by a more hopeful, humane and scientific point of view.

The leader of the new type in industry is studying men. He pays good wages, he maintains a model plant, he makes it possible for his employees to hold up their heads and be men. The new industrial leader recognizes that human energy can only be released and properly guided by utilizing the motives which underlie and determine human conduct. It may again develop into a case of democracy and many mistakes versus autocracy and smooth action. But in view of the peculiar make-up of the human being, autocracy and smooth action may spell inefficiency through subtle forms of sabotage and the lack of zest or interest in the process or in the amount of output.

5. A stable form of industrial democracy must rest on a stronger foundation than the more or less erratic impulses of employers or the war emergency powers of the government. It must rest upon an organization of workers which has a firm footing outside any particular industry. An organization of workers in one business unit without outside affiliations or members, is in great danger of being dominated by the employer and to lack stability and backbone; but a national labor organization stands on firmer ground, its foun-

[2]Hard, *The New Republic*, September 21, 1918.

dation is broader and its outlook less restricted. One essential to the development of industrial democracy is the recognition of labor organizations. "Within-the-family" organizations will almost inevitably be dominated by the most powerful interest which is almost certain to be in such a case the employer interest. However, the most significant step taken in the organization of labor in recent months, the shop steward's movement in England, is essentially a "within-the-family" organization.

Up to date, labor organizations in the United States have been primarily fighting machines; their functions have been mainly protective. The hostile attitude of employers and employers' associations have inevitably produced this reaction. Unions cannot be expected to take any active interest in production problems until their members are assured that the necessity of continuing as a fighting organization is a thing of the past. With increasing participation in governmental affairs on the part of labor, guarantees of a living family wage, greater security of employment, a short working day, and the cooperation of committees of workers with the representatives of capital in business management, a marked and significant change may be expected in the structure, ideals and functions of labor organizations, and in the attitude of their members toward restriction of output and kindred difficulties which now bulk large on the industrial horizon. The instinct of workmanship or contrivance, the creative impulse or spark "cannot actively assert itself until the instincts more directly concerned with immediate survival are given satisfaction."[3] Efficiency in industry or in other forms of human endeavor depends in a large measure upon releasing the creative impulse, upon the joint responsibility of labor and capital. Definite recognition of labor organizations and the participation of representatives of the workers in the councils of industry give promise of being fundamental factors in the next forward step in industry. The War has given the idea of collective bargaining a firm foothold. It was very definitely promoted by the National War Labor Board. The war experience of the nation shows clearly that it should become a permanent factor in our industrial organization.

It is also clear that many union rules and regulations do not permit of maximum productivity. In England, the exigencies of the Great War made it necessary to sweep aside the great mass of union restrictions. Regulations primarily intended to defend unionism have limited output and impaired efficiency. In a large measure, the problem under consideration is one of transforming unionism from being a negative or restrictive force or factor to that of being a positive or directive force or factor in industry. As this salutary transformation is in the process of consummation, restrictive rules will be gradually sloughed off.

[3]Tead, *Instincts in Industry*, p. 150.

Optimists viewing the phenomena of the recent struggle may assert that the old antagonism between labor and capital is on the road to oblivion and that the necessity for unions is now largely of historical significance only. Because business men were quite willing and ready to respond to the call of their country and to put aside personal gain in the interests of the nation, it may be urged that the business men will never again be so unresponsive to the broader or social aspects of business. A well-known man connected with the Fuel Administration in one of the States wrote in a farewell letter to his associates in that service. "You have proved that Americans can act from public motives, that deep in the soul of them is power to respond to a selfless ideal, that latent in the heart of the practical business man is the hunger for service unbribed, unrewarded and self-compensating." Granting that during the progress of the Great War many of the dollar-a-year men and other industrial captains were converted to high ideals and excellent performance in the interest of social and national good, it will indeed be remarkable if a large percentage do not backslide after the pressure and the enthusiasm generated during the War have disappeared and after the prosaic times of peace have re-appeared. There is reason to fear that these new motives will prove, like beauty, to be only skin-deep.

On the other hand, the War unmistakably demonstrated that the support of labor was indispensable to the nation in a national crisis; and, since the government intervened in the operation of so many businesses, the War has also tended to depreciate the importance of the functions of investors and managers. When the United States entered into the Great War, workers were appealed to to speed up and to increase production. But the appeal was for the workers to stand back of the government and the boys in the army. The appeal was not made to loyalty toward employers. It is a sad commentary on modern industry that it has been so conducted and so managed that incentives to better work rest upon considerations entirely outside the industry itself.[4] Now, therefore, is not an opportune time for arrogance on the part of business men; it is the time for careful, intelligent and open-minded study of the industrial situation. We seem to be on the threshold of a new era in industrial relations. The employer who can only think in pre-war terms is a menace to industrial peace. In short, it is asking too much to expect labor to rest its case on the recently awakened social conscience,—a war product. In view of past experience, it must be anticipated that workingmen will continue convinced that union organization is essential to insure that workers will be treated like men and that sufficient emphasis will be placed upon the human element in industry. If the nation is on the threshold of a new era, organized labor must be recognized, bargained with and given a voice in determining

[4] See Marot, *Creative Impulse in Industry*, pp. 57-58. See also *The Nation*, Feb. 8, 1919, pp. 192-3.

working conditions and methods. Under such conditions unions can and will divert their energies from squabbling over the distribution of the output of industry to the new and more alluring goal of raising the level of productive efficiency and of giving the "joy of workmanship" a conspicuous place in modern industry.

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ECONOMICS

THE SOCIAL AND ECONOMIC SIGNIFICANCE OF THE AUTOMATIC TOOL.

ERNEST F. LLOYD.

The subject of the address presupposes familiarity with the automatic tool, but it may be well to take a moment to more definitely fix the idea.

Machinery aids man in the accomplishment of work. In a general or rough way, we may classify it as of three types: Non-automatic or plain machinery, semi-automatic machinery, and full automatic machinery. You will observe that in such a classification there can be no hard and fast lines between the various types, but that the two extremes merge one into another through the intermediate.

Thus a lever, or shovel, or a primitive lathe, such as is commonly found in oriental countries and which merely spins a piece of material to be worked upon, may be included definitely in the first, or plain non-automatic class. These simply assist the worker in accomplishing his purpose. Any one who has been amused at the antics of a non-mechanical person endeavoring to use a crowbar will at once recognize that while the lever is a tool, it is one by which the worker's purpose cannot possibly be accomplished unless he himself possesses full knowledge of the purpose and the method by which he can make the tool assist him.

A semi-automatic tool would be, for instance, the plain lathe to which I have just referred with the addition of, let us say, the lead screw. I well remember being told by the late Andrew Harvey, of Detroit, that his father with a hammer and cape chisel could chase a vise screw thread on an iron bar in half a day. The elder Harvey's training preceded the addition of the lead screw to the lathe. This attachment enabled the worker to chase a very much more accurate thread and in a fraction of the time. But the worker was still under the necessity of understanding how the lead screw acted and of adapting his work within its possibilities, though the skill and training required to do so were greatly reduced.

The full automatic tool, on the other hand, is one which contains within itself the means of accomplishing a purpose without need of the operator having any knowledge of the necessary steps. Thus, a farm boy may get a job in a machine shop. He will be put to work on an automatic screw machine and in the course of a few hours will turn out perfect work and at a rate of speed infinitely beyond that possessed by either of the former workmen. Moreover, if a skilled worker were put to work on an automatic screw machine,

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he would require nearly the same length of time to learn its operation as is required by the farm boy, and when he had learned it, would not be able to turn out with it any more work, or work of better quality, than the farm boy. This is the essence of automaticity in machinery. The full automatic tool reduces the man factor in production, that is, the human element, to the irreducible minimum.

Of course, it is not to be inferred that this fact of producing commodities with wholly unskilled labor by the use of the automatic tool, entirely dispenses with the need of trained skill in industry. That would be a wholly erroneous conclusion. To this I will refer later. But it does have, nonetheless, a definite social significance. The automatic tool has made possible the employment not only of unskilled men and boys, but of women and girls and, if we might be permitted to digress, it would be exceedingly interesting to point out that it was the American automatic tool which in reality was one of the prime factors in the final winning of the war. Perhaps we might rightly say this was both a social and an economic effect of the tool, but I shall not attempt to follow that phase of it this morning.

From what I have said, you will understand that the modern automatic tool is necessarily the result of a long growth. This growth began in many lines very early after the industrial revolution. In fact, inventions which are commonly considered to have constituted the industrial revolution were in themselves the incorporation into machinery of functions that had previously been exercised manually. Nonetheless, this growth was a very slow development during the entire nineteenth century. It was, indeed, not until almost the decade of the '90's that what we now designate as automatic machinery really made its appearance. The turning point came in the first decade of the present century, and so swift was the change that we might be justified in designating it as a second industrial revolution. At least, it was one of those departures that must ultimately impart to civilization a new direction. It is in this sense that we are to consider the social and economic significance of the automatic tool. I propose to discuss its effects more or less under specific heads. I say "more or less" because it is very difficult to precisely determine where an effect may be social and where it may be economic and again where it may partake of both.

Increase of Human Power. The cost of anything made by man is at bottom the total quantity of human brain and muscle which go into its production. Inasmuch as we have seen that the automatic tool enables an article to be produced with the least total of human functioning, therefore it enables man to produce a given thing for the least cost. We may resolve this fact into either of two practical results. First, as the automatic principle is applied in industry, we are able to maintain any given standard of living with a continually decreasing quantity of total human effort, or second, we may

expand our consumption of commodities without increasing the human effort.

We see both of these proceeding simultaneously in current life in that the hours of labor are steadily decreasing while the standard of living is steadily rising.

Decline of Apprenticeship and Trade Skill. The first natural effect of the ability to produce commodities by unskilled workers was to give the death blow to the whole previous system of apprenticeship in the various trades affected. That is, if a worker can be trained to make commodities of one kind after a short period of instruction, naturally he can be re-trained in another similar occupation in a not longer time. The knowledge which was imparted to him under the apprcenticeship system ceases to be necessary and, therefore, the system becomes obsolete. Now, the social consequences of this have been very considerable. The old apprenticeships provided in themselves a certain sort of culture. The skilled worker was a distinctive personality. In its higher aspects, craftsmanship took on the attributes of art. It provided in large measure for the satisfying of ambition, for an expression of idealism. Craftsmanship bespoke long training and intelligent application. It represented a very definite achievement and position in a scale of social values based upon natural ability. A machinist was not a little an aristocrat in his own circles.

All this is absent in the "tender" of the automatic tool because, as I have pointed out, he may be trained for his work in anything from a few hours to a few days. He really puts nothing into this training except merely the acquisition of a manual dexterity, which can be quickly diverted to any other similar process of work. So the modern industrial worker may be a foundry worker, a machine worker, a wood worker, or a worker in any other specialized trade, or in any half a dozen specialized trades, all within say, a month's time. The old demarcations have ceased to exist.

Rise of an Unskilled Body of Industrial Workers. What I have previously said of course had the immediate effect of breaking down the old trade distinctions and consequently of weakening the trade union idea. We see the results of this in trade union statistics. I believe that the high water mark in the membership of the American Federation of Labor was reached in 1904 and that since that year they have hardly held their own and of course, relatively to the growth of industrial activity, such standing still means in effect a great falling off.

On the other hand, the number of industrial workers has vastly increased. These workers are not affiliated with any of the old time trade unions. Nonetheless, any group of men engaged in similar occupations and under the same general surroundings have a distinct tendency towards a solidarity of feeling, and we see such a feeling markedly growing in this country since 1905. I shall deal more particularly with this important phase further on.

Widening of Opportunities for Employment. From what has been said as to the quick change which may be made by the individual from one trade to another, it will naturally follow that the opportunities for employment by industrial workers have been very markedly widened through the instrumentality of the automatic tool. Not only this, but the worker need not be continuously an industrial worker. He may vary his employment in a great variety of ways. Thus, he may be a factory worker, an agricultural worker, or a worker in any sort of manual occupation, and he may change from one to the other at exceedingly short notice—so short, indeed, that he does not consciously notice an interruption in the continuity of his activity.

Narrowing of Trade Interest Causes Economic Unrest. Of course, from the preceding analysis, it will be evident that the trade interest of the individual worker has been narrowed practically to the point of extinction. He is no longer a moulder, a machinist, a brass worker, etc., he is simply an industrial worker. His work, therefore, has become depersonalized and solely an economic activity and as such cannot provide him with an outlet for any possible idealism. Whatever his ideals may be, and no man, however poor, can exist or does exist without ideals in some form or another, nonetheless, as distinct from the old trade worker, the modern industrial worker must find an outlet for his idealism outside of the daily work in which he is engaged. But inasmuch as this daily work practically taxes his physical energy to the point of absorbing all of it, the ideals which he may espouse are most likely to be in a direction of reaction against his daily employment. This, of course, makes a fertile seedbed for revolutionary economic doctrine.

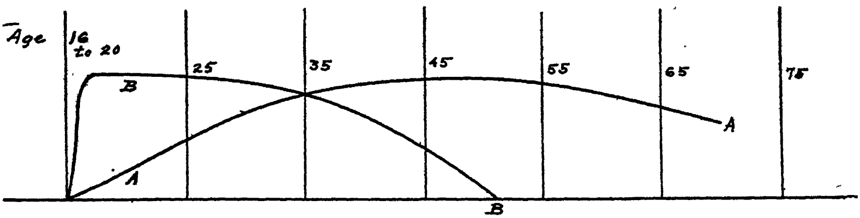
Concentration of Skill. I have previously indicated that the advent of the automatic tool did not destroy the necessity for some craftsmanship. What it has done in reality has been to create two distinct groups in indusry. On the one hand are a very large group of unskilled industrial workers engaged in actual production of commodities and on the other hand are a relatively small group of highly skilled craftsmen through whose efforts the larger group functions. These craftsmen, of course, under the new conditions, require a very much higher knowledge than was necessary in industry prior to the coming of this separation. The early apprenticeships would be entirely inadequate for a sufficient training for most of them. So we find the higher of this training now given in our various schools of Applied Science, such as the Engineering Departments of our universities. The needs of its lower levels are met by the technical high schools and, to a large extent, in the industries themselves. It is the latter of this trained group that at present really supports the membership of the old time trade unions. Nonetheless, the separation of the workers into these two main groups and the resultant change in the outlook on life must be regarded as having a social significance of the first magnitude.

Equalization of Labor Reward. Under the conditions of interchangeable

occupations which I have noted, it will be observed that the natural result is to equalize the pay among the entire unskilled group, simply because as workers can flow from one sort of occupation to another freely, they naturally distribute according to the pay obtainable. This in the long run is a levelling process. It is for this reason that the day laborer in the ditch is rapidly approaching the same rate of pay as the industrial worker in the factory and the progress will probably continue. Whether this is a levelling up or a levelling down, I leave to your own determination, but at all events, it is an economic significance of the automatic tool.

Duration of Industrial Life. The fact of employing only manual dexterity or physical strength, introduces into the mechanic industries a time limit which had not previously existed. We can best illustrate this by a comparison.

The skilled worker of the nineteenth century began what he ordinarily might look forward to as a life work by an apprenticeship commencing between his sixteenth and twentieth year. His period of indenture served to inculcate a knowledge of his craft which was, however, by no means sufficient for the acquirement of a final technique. Throughout his whole active life he continually added to his trade worth by a steady accretion of manual skill and shop wisdom. This trade worth was therefore a combination of physical and mental powers. The best shops were always manned by due proportions of men of all ages. The result in the individual worker may be symbolized by a hypothetical life efficiency curve, as A.. (Fig. 1.)



The automatic tool has, however, revolutionized this condition. Since only the worker's physical capabilities are now required, he may enter an industrial life at any age at which he can stand the pace, say from sixteen to thirty. As we have noted, his training for his particularized task is accomplished in a few hours or days. His maximum dexterity and hence his maximum productive efficiency is attained within a very short time thereafter. Further practice will not accelerate it, while on the other hand its ultimate decline must follow the decreasing curve of his physical resiliency. Naturally, this decline will be in measure a personal equation. The automatic tool is not yet old enough in industry to determine the average maximum age at which a worker must relinquish its operation.

We may, however, say that the length of industrial service must be much shorter than under the old regime, possibly approximating curve B. We shall therefore have to solve the problem of occupation for able-bodied workers who have become too old for industrial production.

Labor Turnover. The turnover of labor in modern specialized industry has finally attracted very wide attention and many schemes are being suggested for abating its undoubtedly evil effects. None of these schemes seems to have taken note of the fundamental bases of the condition. Chief among these is the excessive monotony of the muscular effort required in automatic tool production. Lesser but still important causes are to be found in the impersonal character of the relation of the worker to his work and in the ease with which temporary relief from the monotony can be found through work of a different character which, as I have before indicated, may be readily undertaken.

So much for what may be termed direct consequences. I come now to a set of effects which do not have so close a connection with the tool process as those which we have heretofore discussed. I shall note only a few of them.

The Decrease in Parental Control. I have endeavored to show that through the automatic tool industry can make use of wholly ignorant laborers. This is commonly recognized in the great number of foreigners so employed. But also in the production of many commodities there is much work of a light character wherein nimbleness or quickness or deftness is of more importance than strength and in which the young are more productive than the adult. Industry therefore can absorb children literally as fast as the law allows. This is, generally speaking, by the age of sixteen. Now, as we have seen, these children do not have to follow an apprenticeship with its long and tedious processes and nominal wage. They can at once go into fully efficient production. They are as economically valuable, that is, they can *produce* as much, as at any later time in their lives. They are also, as a rule, more profitable to the employer, simply because their experience as well as their cohesion or trade solidarity is less by reason of their immaturity. They are therefore not capable of making and sustaining the demands of adults. Nor does the social consciousness demand that they be paid as highly. Consequently, certain classes of employers seek them. We have here two results: First, the exploitation of child labor, which is, of course, not a new thing, but which is taking on a new and more extended form, and secondly, we have a self-sustaining wage rate paid to these children, with the consequence that they become economically independent of the family tie. It is a short step from this economic independence to social independence. The child can leave home without fear for his support. As a consequence, in all classes of society we have the phenomenon of the breakdown of family discipline or the lack of parental control, after about the child's sixteenth year.

Increase of Juvenile Crime. Of course, these children so to speak shot out into the world, do so with a social immaturity which is not at all compensated for by their economic self-sufficiency. They are at that age when they crave excitement without feeling any sense of responsibility for their acts and we at once have an explanation for the tremendous increase in juvenile crime. In the language of a Michigan judge, his court has become "a perpetual procession of beardless boys."

Growth of Commercialized Amusement. I have spoken before of the monotony of machine production of commodities. Measurably the like conditions apply to all business. Whether the worker operates an automatic tool in a factory or an adding machine in an office, the mental activity is in either case narrowed and concentrated within a very limited sphere and both mind and muscles exercised soon become tired or, relatively to others, overtired. Some way must be found to restore the mental or physical balance. Mere rest from physical exertion, if the mind is diverted, will restore the physical balance while restoration of mental balance is facilitated by some physical exertion. We find, then, as a consequence, an enormous increase in commercialized amusement in the industrial countries, showing itself naturally first in the United States where the automatic tool was originated and developed. Baseball, the movies, drink, sports and games have become necessary counter irritants, and we find men thus regularly following some non-productive activity. Such men used to find relaxation in an alternative useful occupation. These diversions, of course, involve also a tremendous "social overhead" in the cost necessary to supply them.

The I. W. W. The last point upon which I will touch is the social phenomenon known as the Industrial Workers of the World, to the causes of which I have previously alluded. If we take the uneducated group employed on specialized industrial production, and add to it the ordinary labor which never has required any education, it is probably entirely safe to say that at least one-half of all modern workers, in the earning of a living, can find no use whatsoever for even a knowledge of how to read and write. Nonetheless, our ideas of education compel the imparting of this minima, but they do not compel us to insist on anything more. Hence a boy or girl can leave school with practically nothing more than the simplest rudiments of reading and writing and figuring. Some years ago, Ayres indicated[1] that half of all our children leave school permanently before the completion of the eighth grade and, in fact, a large proportion of this half drop off about the middle of the fifth grade. Now, that means an immense mass of people in the country who can merely read and write, and who can therefore be reached by any sort of propaganda and yet who have no educational background by which to judge the merits of what they read. They are those to whom may well be applied the old proverb,

[1]Laggards in our Schools, p. 71.

"A little knowledge is a dangerous thing." They are a most fertile field for revolutionary socialistic agitation, and agitators naturally do not fail to take advantage of their opportunity. Out of all this we see the natural reaction, a group antagonistic to all our present social ideas. Though there may be elements of justice in their economic views, they at least can have not the most elementary conception of the means by which their ideas might be put into effect. They are, therefore, simply social revolutionaries, counselled to and largely bent upon destroying the existing social organization and with no plan whatever for its reconstruction. They frankly avow that they have nothing in common with the rest of society.

I have endeavored in the foregoing to hold to my title and simply point out some of the social and economic consequences of the introduction of the automatic principle into machinery and more particularly the apparent effects of its wide and extensive application under our existing social order. This is not, perhaps, the proper occasion for an attempt to point out constructive measures for its control. That would be a quite sufficient subject in itself, and while an analyst may naturally come to some conclusions they would not be comprised within the title of this address.

Ann Arbor, Michigan.

POTENTIAL COMPETITION AS A SAFEGUARD AGAINST PERMANENT MONOPOLY.

RUSSELL D. KILBORN.

Addressing the British Association for the Advancement of Science on the subject "Industrial Combination" in 1890, President Hadley, generally regarded as an orthodox economist, took the position that we may adopt one of three policies in dealing with the problem of industrial monoply. The three policies are:

1. Recognition of trusts as monopolies with some form of regulation.
2. Prohibition of monopoly.
3. Laissez-faire policy.

For reasons that need not concern us, he rejected the policies of regulation and of prohibition and urged the adoption of the laissez-faire policy. The argument advanced in support of the policy was about as follows: Monopoly is superior to big business for the production and sale of commodities. But the monopolist because of the absence of competition will charge such prices for his commodities that his profit will be above normal. This stimulus will attract new capital into the field and as a result of the ensuing competition prices and profits will drop to their normal level. After two or three experiences of this sort, the monopolist and all others like him, will profit by the lesson and be content in the future to charge such prices for his goods that the stimulus for new capital to enter the monopolized field will be lacking. These prices will be normal, or so nearly so, that the problem will either be solved by the spontaneous action of economic forces or will cease to exist.

In a book published in 1900 Mr. Price Collier, New York State Civil Service Commissioner, states that competition is the mother of trusts. The inevitable tendency of competition is combination, so he asserts. As different firms or corporations compete with one another, one is left in power and a monopoly more or less complete is the result. The reason that one firm as distinct from any other is able to survive is because it is the most efficient of all those engaged in producing the same good. But society has a safeguard from exploitation by this monopoly because new capital will enter the field when the monopoly charges such high prices that the return to the monopolist is above the normal return. Consequently, the policy to be followed in dealing with the problem is to place reliance upon potential competition.

Professor Jenks completely revised and enlarged his book "The Trust Problem" in 1917. This author, long recognized as an authority on the trust

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problem, seems to take about the same position as Mr. Collier. The whole trust movement, so we are told, can not be understood or appreciated unless we look at its genesis, the competitive regime. The capitalistic monopoly has emerged from the competitive regime because of the large amount of fixed capital required in certain lines of modern industry, the fierceness of competition between corporations having these large fixed investments, and the ability of the trusts to realize large savings impossible for an independent concern to effect. But these trusts have their teeth pulled, so to speak, by potential competition which will become actual when the profits of the monopoly are above normal. In support of this he cites the case of the Sugar Trust which has been compelled to face the competition of first, the Spreckles interests, and later of the Arbuckles and Doscher interests. Now (1917) they have learned their lesson and the price charged for sugar is sufficient to yield a normal profit.

These statements coming from three different men over a period of more than a quarter century reveal quite conclusively that there has been and still is a widespread belief in the efficacy of potential competition as the sole means for safeguarding the interests of the public, even though monopoly according to these writers is to be a permanent phenomenon in certain fields of industry. The persistence of this belief is the more remarkable in view of the penetrating article written on the whole subject by Professor Bullock in 1901. He has made a distinct contribution to the whole problem by proving that those writers who insist that monopoly is inevitable in those fields of business where a large amount of capital is necessary for the productive process and who then insist that potential competition can be relied upon as a safeguard against permanent monopoly are guilty of an inconsistency. They argue on the one hand that monopoly is more efficient than business organized under competitive conditions and then they would have the danger of monopoly removed by appealing to potential competition to come in. This can not continue for any length of time because potential competition can function most effectively in businesses competitive in their nature.

He has also shown that even if potential competition is to be the means by which we are to regulate monopoly, the results would be disastrous for two reasons. First, potential competition would be able to distribute but a small share of the alleged advantages of monopoly among consumers. Mr. Bullock instances the case where a corporation having a monopoly can make and sell a commodity for 80 cents; but the potential competitor can not make it for less than $1.00. Under such conditions all that potential competition can do is to keep the price of the commodity from going higher than $1.00, for the monopolist can raise the price of the commodity up to any figure less than $1.00 and still keep the potential competitor out of business. Assuming that the monopolist does charge $1.00 for the commodity and potential competition

does become actual, all that the monopolist need do is to drop the price and drive the competitor out of the field. Consequently, the consumer does not obtain any of the gain from the economies effected by the trust.

Second, even if potential competition does become actual, the result would be nothing but a waste of capital on the part of the competitor. The reason for this is to be found in the fact that according to Jenks, *et altera*, the monopoly in question can make the commodity cheaper than a possible competitor. If, therefore, the price of the goods is advanced so much that potential competition becomes actual, all the monopolist need do is to lower the price and the competitor is driven from the field. The capital of the competitor will be a total loss or else partly wasted.

In reaffirming the proposition of Professor Bullock that potential competition can not be relied upon as a safeguard against permanent monopoly, I am doing so for reasons quite different from those advanced by him. The argument advanced against the proposition that potential competition *per se* is a safeguard against permanent monopoly is based upon the idea that such wastes as accrue to the potential competitor when he invades the field where monopoly is superior or more efficient differs from those that exist under modern competitive conditions, not merely in amount as Mr. Bullock has suggested, but in kind. The reason for this difference in kind is to be found in the difference in the processes of price determination in the two cases. The mere statement of this point will not carry conviction, and so I pass to a defense of the proposition.

The difference between the two cases can best be brought out by the use of illustrations. Let us assume that the X. Y. Z. Corporation has a complete monopoly of the mining and refining of borax in the United States; and because of the economies which it is able to effect, it can mine and refine borax at a price of 8 cents a pound. But a competitor being unable to realize these economies can not put the commodity on the market for less than 12 cents a pound. The X. Y. Z. Corporation being desirous of obtaining the maximum revenue proceeds to raise the price of borax to 12 cents a pound with the result that the competitor comes on the market. Afer a short period of competition the monopoly, the X. Y. Z. Corporation, reduces the price of borax to 11 cents a pound and the competitor is driven from the field. His capital in the form of tools, machines, buildings it lost. This constitutes a loss of capital such as we are familiar with in the competitive struggle.

Let us consider what happens under a regime of perfect competition such as the theorist hypothecates. As an example, let us take the case of the production and sale of copper. For some reason, say a war, there is a great increase in the demand for copper. And in order to supply this demand, the old mines are using ore of an inferior grade as well as going deeper into the earth and new mines are opened. Let us assume that seven new mines are

opened and that mills are built and machinery of a suitable kind installed. Presently the war is over; the demand for copper falls off to such an extent that the seven new mines and the mills used in conjunction with them can not get the copper out and refine it at the low price. These mines are closed; and the capital in the shape of machinery, stamping mills and the like is lost.

On the surface it appears that the two cases are identical. In both instances potential competition became actual because of a rise in price. Moreover, there came a time when the price of the commodity is decreased with the result that the potential competitor is driven from the field with a loss or at least a waste of capital.

Nevertheless, there is an important and fundamental difference in the two cases. In the case of copper the price advanced from 13 to 35 cents a pound because of the inability of the producer to supply the total demand at the old price, 13 cents. Had he been able to supply the total demand at the old price, the price would not have gone up. But he was unable to do so. The extra-marginal producer or producers came on the market because of this fact. The function of potential competition in this case is to keep the price from going higher than 35 cents. That is to say that the added supply of copper brought on the market by these men keeps the price of copper within due bounds. In the way the extra-marginal producers have the same effect upon the price of copper as the inferior grades of land have upon rent. If they did not come upon the market the price of copper would have gone even higher than 35 cents a pound.

No such function is performed by potential competition in the other instance. Here the price of borax went up, but not because of the inability of the producer to put the commodity out at a lower price because according to the assumptions of Jenks and the others any amount of borax can be put out at the old price of 8 cents. The competitor came in then, not because of the inability of the producer to satisfy the total demand at his cost price but because of the law of monopoly price. The new price is not the right price because it does not correctly guide us in the best use of our productive capacities; the new price in the case of copper is the right price because it does guide us correctly in the use of our productive resources. The vital difference between them is to be found in the fact that in the case of copper the new price is due to the inability of the producers to get out the total supply at any price less than 35 cents a pound; in the case of borax it is due to a different principle of price determination.

If the foregoing analysis is sound, we can conclude that the wastes that accrue when potential competition invades a field where monopoly is the most efficient unit for the production and sale of commodities are less justifiable than those that occur in businesses essentially competitive in their nature. We have already recognized the importance of this point as applied to public utili-

ties and have come to feel that duplication of plant and equipment involves a waste of capital less justifiable than in industries working under a competitive regime. Moreover, we do not place reliance upon potential competition but have adopted a comprehensive scheme of government control.

Are we to conclude then that potential competition has no part to play in solving the problem of industrial monopoly? I think not because it limits the field within which the monopolist may exploit the consumer. In the example of borax previously mentioned the presence of potential competition can keep the price of borax from going higher than 12 cents a pound. It is not necessary that the competitor come into the field in this case for his mere presence is sufficient to keep the price of the commodity within due bounds. The same function is performed by potential competition in the case of public utilities but the limits are doubtless much greater. If the limits are very narrow in the case of industrial monopoly the function performed by potential competition is such that it merits a great deal of importance.

University of Michigan.

PELATIAH WEBSTER AND THE REVOLUTIONARY CURRENCY.

EARL V. DYE.

Pelatiah Webster was born at Lebanon, Connecticut, in 1725. He graduated from Yale in 1746, studied theology, preached for a year, turned to literature for a time and finally in 1755 went into the mercantile business in Philadelphia, in which calling he amassed a fortune. Much of his estate was confiscated by the British army during their occupation of Philadelphia and imprisonment by Lord Howe impaired his health.

Webster is best known to students of Constitutional History. In February 1783 he published a tract of forty-seven pages entitled, "The Political Union and Constitution of the United States of America which is Necessary for Their Preservation and Happiness, humbly offered by a citizen of Philadelphia." Webster was referred to by James Madison, himself, as the "Father of the American Constitution," an honor which students of the subject today do not accord him. Webster's house in Philadelphia was, however, the gathering place for the literary and political leaders of the day among whom were Hamilton, 26 years of age; Madison, 32; and Pinckney, 26. That the trained financier and economist of 57 should have had considerable influence on these younger men, each of whom presented a plan of government to the Constitutional Convention, can not well be doubted.

The list of Webster's articles and tracts on finance and government fill nearly a page in "Dexter's Yale Biographies."

The first issue of continental paper money was provided for June 22, 1775, five days after Bunker Hill. By December of the next year $25,000,000 had been issued. This was continued until by the end of 1779 $241,553,780 had been issued besides $209,524,176 of state currency. Webster's first discussion of the value of money was published October 5, 1776, fifteen months after the first issue, at which time Webster did not think depreciation had begun, ascribing the higher prices to increased demand and the disruption of trade. Here at the outset he recognized the operation of two forces which, if they had been considered, would have prevented or greatly modified the evil price regulations of the time. Whether or not depreciation had set in at the time Webster wrote, is even today a matter of dispute; Bolles agrees with Webster, Summer thinks it began with the first issue, and Bullock says that in the last months of 1776 depreciation was very slight and gradual.

21st Mich. Acad. Sci. Rept., 1919.

At any rate the essay was written when depreciation was, at most, very slight; and when, if it existed at all, it would have been discernible only to a keen student of the subject.

In the first essay Webster says that, if the quantity of the currency is greater than that required for a medium of exchange, it will show itself in several ways; estates will be vested in goods of intrinsic value and hoarded; foreign trade will be discouraged because, in his words, "no one will import goods for a medium that is worse than the goods themselves; for, though the profits may be nominal, the loss will be real." "It will discourage industry for the same reason."

These conditions which Webster clearly foresaw, later became the chief causes of the difficulty of providing for the American army and, incidentally of the suffering at Valley Forge and Morristown and they placed in jeopardy the cause of the Revolution.

These effects Webster thought could only be avoided by lessening the amount of paper money and this decrease must be accomplished by taxation; to quote him, "This tax ought to be equal to the excess of the currency, so as to lessen the currency down to that quantity which is necessary for the medium of trade, and this in my opinion ought to be done by every state, whether the money is immediately wanted in the treasury or not, for it is better for any state to have its excess of money, though it were gold or silver, hoarded in a public treasury—than circulated among the people." He then uses a rather unfortunate illustration in which he confuses money and wealth. After an eloquent appeal, he tells the colonists that there is no way to finance the war except by taxes and that if they do not tax themselves, "as the price of their liberty, their conquerors will do it more heavily as the price of their chains." They cannot carry on the war by means of paper money, for, he says, "I conceive the value of the currency of any state has a limit, a *ne plus ultra*, beyond which, it cannot go, and, if the nominal sum is extended beyond that limit, the value will not follow." "Any attempt to extend such nominal value must depreciate the whole. This limit, the amount of money which was needed for trade, he estimated at eight or nine million dollars in 1779. The nominal value he placed at $160,000,000.

In August, 1779, Webster wrote that it followed from the above principle that the debt had not increased for three years, that probably it was even less. The expense of the war had then been born by taxation, but it was the worst possible kind of a tax falling heaviest on widows and orphans."

In the three years following 1776 he estimated the depreciation to be 50 per cent per annum. It is, he says, "easily demonstrated, yet so subtle as to lead to remedies worse than the evil."

Among these evils are the price schedules. In discussing them, he says, "the value of money is nothing in itself, it is a mere relation, it is the propor-

tion between the objects of trade and the medium of exchange; these two will always balance. Therefore if the medium of exchange increases while the objects of trade continue the same, the money must depreciate; if the medium of exchange increases while the objects of trade decrease, the proportion will alter still faster, and the depreciation will increase in a double proportion, which I take to be the present case."

In his discussion he gives full recognition to the importance of velocity of circulation. We have then all the elements of the equation of exchange except the mathematical form and credit instruments, and these were a negligible quantity for his day.

It will be seen also, I think, that his propositions assume the quantity theory of the value of money. For example, he says, if a country needs $10,000,000 to carry on its trade and it is suddenly increased to twenty million, the increased amount will have the same value as the lesser amount, that is the value of the dollar is one half or varies in inverse proportion to its amount. Figuring up the amount of money needed by the country in 1779 he found it to be nine millions dollars; figuring up the real value of the currency, he found it to be only three million and he adds that this was due to the lack of faith in the government. Whether or not he was aware of any inconsistency, he does not give the slightest indication; and, in any case, I feel sure he would not have cared. He was not interested in a theory of money or a theory of anything else, except insofar as it would assist him in gaining popular support for financial reforms. For this purpose simplicity was of much greater value than scientific accuracy.

In spite of these warnings the emissions of paper continued. By 1780 the emissions of paper money totaled over 241 million dollars, and finally in 1781 by a trick of the Pennsylvania Government it ceased to circulate entirely. For this depreciation, Webster had one remedy which he preached on all occasions, in season and out, that was taxation which he thought practical. This will be discussed later but first we will consider two other remedies which were very thoroughly tried, namely price regulation and loans.

Because the burden of loans through the issue of paper money or of loan certificates was borne at the time by depreciation, and in an extremely unjust fashion; because of the danger, as he saw it, of financial dependence on a foreign power; because exchange and insurance rates were each 50 per cent; and because as, he clearly pointed out, the strength of the country lay in its resources and man power which were amply sufficient and had scarcely been tapped; because of these things, Webster opposed all loans, except for the small amount of equipment which must be bought abroad. I shall not carry the matter farther except to read one short quotation, which I think will be of interest in view of recent discussions of war finance. If I should put it side

by side with certain passages from Professor Sprague's article I think you would be impressed with the similarity.

Webster says, "people should be taxed, in proportion to their abilities, but then I think it very necessary that they should pay as they go, as near as that may be. The soldier renders his personal services down on the spot, the farmer his provisions, the tradesman his fabrics, and why should not the monied man pay his money down too. Why should the soldier, tradesman, farmer, etc., be paid in promises, which are not so good as money, if the fulfillment is at a distance."

From the very first Webster talked taxation, he said the enormity of the debt was more in sound than substance. He estimated the population at 3,000,000 and the minimum price of wheat was $20.00 per bushel; so that a quarterly tax of one bushel of wheat per head would have yielded $240,000,000 a year. In 1780 Webster estimated the probable expenditure for that year at $11,000,000 and he figured that in 1779 the Colonists had paid $19,000,000 through depreciation. The Colonists were fighting a war against taxation, however, and his many years' sowing was on stony ground.

On economic problems, I believe Webster was the clearest thinker of his day and country. He was not a scientific economist. He formulated no economic system. Like Ricardo and others of the classical school, Webster was a propagandist. His efforts were directed to the solution of very practical problems and he went no farther.

University of Michigan.

THE DEVELOPMENT OF AN ACCEPTANCE MARKET IN THE UNITED STATES.

RAY V. LEFFLER.

"Credit is the lifeblood of business. One of the principal channels through which it flows is the acceptance, or time bill of exchange." In England, France, and Germany, the acceptance credit system is very old and has been thoroughly developed, while in the United States it is comparatively new and not so well understood.

On November 14th, 1914, the Federal Reserve System was put into operation, and to that system we owe the real beginnings of an acceptance market in this country. The principal idea of this system is to secure the liquidity of bank assets,—that is the possibility of readily and quickly converting them into money. In the case of commercial banks these liquid assets must be furnished by the different businesses which are the clients of the several banks, and so the initiative must come from the business men of the country, through the methods used in financing trade transactions, viz.: the furnishing of a supply of liquid commercial paper very largely by means of acceptances.

As an illustration of an acceptance,—suppose that a seller of goods draws a trade bill upon the buyer for the amount of the bill, and payable at sight in sixty days, then the buyer writes across its face the word "accepted" and signs his name with the date of the acceptance. Thus is created a credit instrument of the better sort,—a trade acceptance, and which, from the banker's point of view, is the ideal form of commercial paper, since it bears two names, represents a self-liquidating transaction, is almost certain to be paid at maturity, and may be converted into cash by offering it for rediscount at a Federal Reserve Bank, at a preferential rate, or by sale in the open market.

The bank acceptance differs from the trade acceptance in that the seller draws the bill upon the buyer's bank instead of upon the buyer. The bank accepts the bill, according to arrangements made in advance with the buyer, and then sends it to the seller, who in turn may sell it in the open market, discount it at the bank, or hold it until maturity.

From the business man's point of view, the acceptance enables business to be transacted at a smaller operating cost; it reduces the amount of losses from bad debts, and it does not decrease buying power but assures a safeguard against over-buying. The general benefits of the acceptance are not to be disputed, but not until this credit instrument is more fully understood, and some of the difficulties are overcome, will its full advantages be secured.

The acceptance has a separate and distinct use. A few of the most ardent supporters of an American acceptance market have created the impression that acceptances were to displace other systems of credit such as commercial paper, and the cash discount for early settlements. This is not the case however, and acceptances should be used only when credit is required by the seller and when the buyer is willing to grant it. So businesses, which are able to carry on their trade transactions on a cash basis, or by borrowing on their own paper or against collateral, may assume an air of indifference toward the acceptance. The acceptance has not come as a revolution in our credit system but rather as an evolution and a supplement. So much for the setting of an acceptance market.

SOME LEGAL ASPECTS OF THE ACCEPTANCE IN THE UNITED STATES.

The Bank Acceptance. The Federal Reserve Act has defined what shall be considered as eligible bank acceptances for member banks. It states that a member bank may accept drafts or bills of exchange, having not more than six months to run, exclusive of days of grace, drawn upon them for importation or exportation of goods, or domestic shipments accompanied by title documents or warehouse receipts, as follows:

(a). For any one person, firm or corporation up to an amount equal to not more than ten per cent of the bank's capital and surplus, if unsecured by either attached documents or other collateral.

(b). Aggregate acceptances at any time shall not exceed 50 per cent of the bank's capital and surplus, except that by permission of the Federal Reserve Board such acceptances may equal 100 per cent.

(c). The aggregate amount of domestic acceptances shall in no event exceed 50 per cent of the capital and surplus of the bank.

The Federal Reserve Board, in its regulations, has defined those acceptances which are eligible for purchase by a Federal Reserve Bank, and so these acceptances constitute practically the only kind that will be presented in the market. In this case, a banker's acceptance, within the meaning of the regulations, is a bill of exchange of which the acceptor is a bank or a trust company, or a firm, person, company, or corporation, engaged in the business of granting bankers' acceptance credits.

To be eligible for purchase, the bill must have a maturity of not more than three months, exclusive of grace, at the time of purchase and drawn under a credit involving "(1) The shipment of goods between the United States and any foreign country, or between the United States and any of its dependencies or possessions, or between foreign countries, or (2) The shipment of goods within the United States, provided that the bill at the time of its acceptance is accompanied by shipping documents or (3) The storage within the United States of readily marketable goods, provided the acceptor of the

bill is secured by warehouse, terminal or other similar receipt, or (4) The storage within the United States of goods which have been actualy sold, provided the acceptor is secured by the pledge of such goods, or it must be a bill drawn by a bank or banker in a foreign country or dependency or insular possession of the United States for the purpose of furnishing dollar exchange."

Thus we find acceptances, eligible for purchase by a Federal Reserve Bank, restricted to those covering imports and exports; to those necessary to create dollar exchange in order to stabilize exchange rates between the United States and foreign countries where there is a demand for exchange on the United States and where the supply is very small; to those drawn against certain produce, such as cotton, which is stored in warehouses waiting to be moved to the final customer; and finally to those arising out of foreign trade between countries other than the United States. The last case should tend to develop our country as a factor in the foreign banking of the world and our foreign banking institutions as important instrumentalities in a new field of endeavor.

The Trade Acceptance. As regards the trade acceptance, the Federal Reserve Board has defined it as "a bill of exchange drawn by the seller on the purchaser of goods sold, and accepted by such purchaser. To be eligible for purchase the bill must have arisen out of an actual commercial transaction, domestic of foreign; that it must be a bill which has been issued or drawn for agricultural, industrial, or commercial purposes, or the proceeds of which have been used or to be used for the purposes of purchasing, carrying or marketing goods in one or more of the steps of the process of production, manufacture or distribution, and it must have at time of purchase a maturity of not more than ninety days exclusive of days of grace."

It should also be noted that acceptances are to be given a preferential rate on the market, for, in its regulations, the Federal Reserve Board has stated that, "Federal Reserve Banks should have in mind that preference should be given whenever possible to acceptances indorsed by a member bank, not only because of the additional protection that such indorsement affords, but also because of the reason that acceptances discounted may be used as collateral security for the issue of Federal Reserve notes."

HISTORY OF THE ACCEPTANCE MARKET IN THE UNITED STATES.

Let us now turn to a short history of the development of the acceptance market in the United States. The actual growth of the use of the acceptance may best be observed by studying the reports of the New York Federal Reserve Bank,—the center of the acceptance market. The second annual report (1915) states that it was not until after the derangement of international credit facilities, at the opening of the European War, that the American bankers' acceptances, especially those relating to foreign commerce, came to be used to any large extent. After that time, several of the trust companies

with foreign connections extended credits freely to their customers to replace those formerly granted by European banks.

From the very beginning of the acceptance market, the policy of the Reserve Banks has been very liberal and they have purchased good acceptances whether the acceptor bank was a member bank or not. While there was the possibility of driving the acceptance business into the hands of the member banks by pursuing an opposite policy, it was felt that the broader policy would be of greatest assistance in developing the necessary market in the shortest period of time, so that eventually the best results would be obtained.

During the first year's history of the market, although the discount rate was lower in the United States than in London, the amount of acceptance credits by American banks was quite small, and was conclusive evidence of the difficulties which were met in the developing of a market. Some of these difficulties were, "(1). The disinclination to break old banking connections, (2). The difficulty of educating handlers of bills in distant places as to American credits, (3). The lack of bill buyers in foreign countries who will quote as low rates on dollar as on sterling bills, (4). The natural prejudice of bill buyers in foreign countries in favor of a bill of known currency as against a bill of as yet unknown currency, (5). The lack of men trained to exercise the judgment and financial responsibility required of them as managers of branches or agencies which American banks might establish in foreign countries. (6). The inferior communications for both goods and mail between the United States and foreign countries as compared with those between Great Britain and foreign countries." Perhaps only much time, experience, and patient effort will remove these handicaps to the elevation of dollar exchange to its proper position in international finance.

The year 1916 witnessed a great increase in the volume of business financed by bankers' acceptances,—the total amount of acceptances bought by Federal Reserve Banks during that year was $386,095,000, as compared with $64,845,000 in 1915. The chief reason for this great increase was the fact that it now became legal for national banks to accept bills covering domestic shipments,—which caused large volumes of staples such as cotton and grain, and metals to be carried within the United States under the Bank Acceptance plan instead of under direct bank loans.

During this year, considerable progress was noted in the development of a discount market. Several of the large banking and brokerage houses had become dealers and specialists in the acceptance field,—purchasing the bills as they were offered in the United States and contracting to buy them when they arose in foreign countries as soon as they arrived in this country. The demand for acceptances from banks and investors began to demonstrate the desirability of such paper as the prime and liquid banking asset, which fact

had long before been recognized in foreign countries. During the latter part of the year, the higher discount rates caused many of the banks outside of the larger cities to make investments in acceptances and so tended to increase the scope of the discount market. During the year also, several trade banks of foreign countries with branches in New York and many private banks filed statements of their condition so that they might be in a position to trade in acceptances in the American market.

For the year 1917, the amount of acceptances bought in the open market totaled $909,301,000, thus pointing out the fact that there was an enormous increase in the volume of acceptances handled and also in the scope of the market. This year marked the more general recourse to bankers' credits for the financing of the large seasonal crop movements, thus indicating that the borrower and the banker alike were beginning to recognize the advantages of this new method of financing trade in the United States. Many smaller and scattered banks came on the market as investors in acceptances, for the first time. Two New York acceptance houses increased their bills sales to the different banks to over $300,000,000 as compared with $60,000,000 the preceding year.

A brief survey of the development of the acceptance market during 1918 showed a more remarkable growth. Prior to the passage of the Federal Reserve Act, very few states permitted banks and trust companies, incorporated under state laws, to accept bills of exchange drawn upon them. The Federal Reserve Act now authorizes the member banks to accept bills, not having more than six months to run, which grow out of foreign shipments, and also those growing out of domestic shipments provided the proper receipts or shipping documents are attached.

The Board had, up to January 1st, 1919, authorized 161 member banks, having $1,000,000 or more capital and surplus, to accept up to 100% of their capital and surplus. The report showed that the purchases were mostly bankers' acceptances, although trade acceptances were being acquired more and more,—in some districts the amount equaled 5% of the total volume, although the average was only 3% for the entire system. The statement of the open market purchases showed a total of $1,818,354,000 for the year 1918.

LONDON STILL THE LEADING MARKET FOR ACCEPTANCES.

The American acceptance market has not as yet outdistanced the London market. Up to this time, our market has developed with practically no competition from other markets and so has been greatly favored and encouraged by a growth which has been very largely due to the stimulus of the great foreign trade during the war. Therefore some writers have felt that New York had already or soon would surpass London as an acceptance market, but the statistics of Mr. Leopold Fredrick of the American Smelting and Refining Company furnish an interesting comparative study of this subject.

These statistics show that, at a date approximately the end of November, 1918, the total amount of acceptances of all the London banks and agencies was approximately $500,000,000, while the total acceptances, in New York, representing the financing of foreign trade, showed an amount of $210,000,000. Mr. Fredrick comments upon these figures by saying that "the foregoing figures show that London is far ahead, and I believe that even with the much-needed improvement of the machinery for financing international trade London will still, for many years to come, outdistance New York. We are lacking here the large number of merchant bankers, and old-established accepting houses with business ramifications all over the globe. We here will be satisfied if we can hold the Central and South American, and Far East business. Although dollar exchange has made great strides since the war, the New York discount market is still in its infancy. For the present there is little likelihood that we will get, except occasionally, the financing of the continental trade of Europe. It is hardly likely that, say an Amsterdam merchant importing goods from France will seek accommodations in New York; he will go as heretofore to London."

In considering the development of an acceptance market in this country, we must always keep in mind the difference in the rates of discount for this kind of paper in London and New York. In London, the Bank of England fixes an official rate, and then there is also an open market rate. The London acceptance bankers ordinarily buy and sell the majority of the bills in the open market, but always have access to the Bank of England for rediscounting, if desirable. So the bank rate is usually fixed for a considerable period of time, while the market rate fluctuates according to the demand for and the supply of bills. The Bank of England, if it seems advisable, may also enter the active acceptance market as a buyer or a seller and so affect the prevailing rate. As to the rate of discount in London, it is the lowest in the world because of the accumulation of funds there from all parts of the globe, which may best be invested in bills of exchange.

In contrast with the English situation, we find that New York is the only broad acceptance market in the United States, and that the rate established by the Federal Reserve Banks is followed closely by the exchange bankers, because there have not been sufficient funds in the New York open market to take up the acceptances offered, and so many of the bills have been transferred to the Federal Reserve Banks for rediscounting, and there has been no tendency for the market rate to fall below the bank rate. When money is easier in New York and the bankers are willing to keep the purchased bills until they mature, then the market rate will tend to be below the bank rate, but not until then.

During the war, the ordinary free movement of acceptances to the market which has the lowest rate of discount has been restricted, and so the New

York market has not been put to the real test of meeting the competition of the foreign markets, but it will be obliged to consider the English rate after a normal condition is resumed, and money flows more easily from place to place.

A PROPOSED CHANGE IN THE LEGAL LIMIT OF ACCEPTANCES.

The Annual Report of the Federal Reserve Board for 1918 points out the fact that, "in a development of the American acceptance market, it is necessary to provide not only an outlet for acceptances, but means of securing acceptances of bills in adequate volume, and in order to enable American banks and bankers to compete with British banking houses in financing the world's trade, the combined power of American institutions, (whose acceptances can be made available in foreign markets), to accept time bills must be large enough to meet all requirements, for otherwise, should importers find that it is only occasionally that they can obtain dollar acceptance credits from American banks, due to the fact that these banks have reached the limit of acceptance liabilities provided by law, the importers will naturally return to the sterling acceptances which are available at all times in sufficient amounts to meet the demand."

The Board, a few months ago, made inquiry concerning the amount of acceptances outstanding in this country and found that the amount was $477,500,000. On this basis, excluding the inland cities which do not accept to any large extent on foreign transactions, it was found that the Atlantic slope cities can accept for only $290,000,000 more, while the foreign trade of these cities, if a large part were financed by dollar acceptances, would require a much larger amount. As a result of this inquiry, the Board suggested that the Act be amended so as to permit any member bank with a capital and surplus of not less than $1,000,000 to accept drafts or bills of exchange, growing out of foreign trade, to an amount not exceeding 200% of its capital and surplus, instead of 100% as at present. This suggestion, if enacted into law, should provide a limit which would be sufficient for the growth of an acceptance market in the United States for many years to come.

AMERICAN FOREIGN BANKING MACHINERY.

It goes almost without saying that the financing of our foreign trade will be greatly facilitated by the organization of international and foreign banking corporations, so it will be worth while to note the development in that line since the enactment of the Federal Reserve Act. At the present time, we find five foreign banking corporations organized under Section 25 of the Act, viz.: (1) The American Foreign Banking Corporation, New York, with four branches. (2) The Mercantile Bank of Americas, New York, with six affiliated institutions, more than twenty offices, two branches and five agencies.

(3) The First National Corporation, Boston, with one branch. (4) The Asia Banking Corporation, New York, and (5) The International Banking Corporation, New York, with twenty-four branches. Practically all of these corporations are operating in Central and South America and the Orient. In addition to these exclusively foreign trade banks, two national banks have established foreign branches,—The National City Bank of New York, with twenty-one branches in South America, Cuba, Porto Rico, Russia, Italy, a representative in Copenhagen, and authorized to establish branches in Belgium, Switzerland, Portugal and Spain; and the First National Bank of Boston with one branch in Buenos Aires. Among the State banks having foreign branches are The Guaranty Trust Company, The Equitable Trust Company, and The Farmers Loan and Trust Company, all of New York, with offices in England and France and agencies in all parts of the world.

In conclusion, we may summarize the acceptance situation in the United States by stating that the necessary banking machinery has been fully authorized by the Federal Reserve Act, that many banking organizations have taken advantage of the opportunity to accept and discount, that the war has been a factor in the rapid development of a market in this country, and in making it unnecessary to submit to the strong competition of the London market, and finally that the future looks even better than the past, because (1) business men are becoming accustomed to the use of the acceptance and are favoring it, (2) a campaign of education by the different banks and the American Acceptance Council is well under way, and (3) the demand for acceptances should expand immensely during the next few months, after the banks are relieved of the billions of government short-term war paper. Mr. Paul Warburg, formerly a member of the Federal Reserve Board, says that, "when we return to normal conditions, it is likely that the Federal Reserve system will be found carrying as a permanent investment a sum very largely in excess of its pre-war normal load, and it is to be expected that then, with war paper out of existence, acceptances will again play the leading role in the Federal Reserve system investments." The future then for the acceptance market in the United States seems very promising, although it is not likely that New York will surpass London, with its history and natural advantages, for many years to come.

University of Michigan.

FARM INCOMES.

EARL D. DAVIS.

The primary purpose of this paper is to formulate some general conclusions regarding the average amount of income received by farmers in the United States, and to segregate, as far as practicable, the various elements which compose this income.

The difficulty of the task at hand is readily perceived. When there is separation in the ownership or control of the various productive factors, it is comparatively easy to evaluate the services or contributions of each one of these factors. But, when all four factors of production, land, labor, capital, and entrepreneurship, are furnished very largely by one and the same person, it is difficult to differentiate the component parts of this single income. This is very generally the case with the agricultural enterprise. As a rule, the American farmer furnishes *his* land, *his* capital, and *his* labor services (including that of his family), and he alone is responsible for the enterprise. Assuming that all of the factors thus represented make a contribution, he ought to receive in income *rent on his own land, interest on his own capital, wages for his own labor*, and *profits for assuming the risks* of the enterprise.

But, before we attempt to apportion the farmer's income into its component parts, we have first to determine what that income is. For this purpose, let us examine the data which the office of Farm Management has recently compiled. It has formulated a summary of the average farmer's earnings for 1909 as follows: The average total farm income including value of crops ($511), value of live stock products ($177), value of animals sold and slaughtered ($288), value of house rent ($125), value of food provided by farm ($100), and value of fuel provided by farm ($35), amounted to $1,236. On the other hand, the average total farm expenditure including outlay for labor, seed, threshing, animal purchases, taxes, miscellaneous expenses ($432), and maintenance charges ($80) amounted to $512. Thus, the average gross earnings of the farmer and farm family amounted to $1,236 minus $512, or $724. But, deducting interest at 5% on the value of the farm property, or $322, the net earnings of the farmer and farm family averaged $402.

Now as a matter of fact, these data set forth the truth more adequately than one might think. Recently a survey was made of 2,090 farms located in Indiana, Illinois, Iowa, Michigan, Pennsylvania, and New York under the auspices of the Office of Farm Management, and the average income per farm was found to be $439. So far as the average income per farm is concerned,

apparently location does not have any material influence. In all cases, considerable fluctuation was found in the amount of net earnings of the individual farmers comprising the community, but the general average did not fluctuate nearly so much. For instance, in Livingston County, New York, which is perhaps the richest in soil fertility in New York, 26% of the farmers made over $1,000, 6% over $2,000, and the rest less than $1,000, the average being $666. In Lenawee County, Michigan, 300 farmers employing an average capital of $11,756 (including land, buildings, live stock, machinery, etc.) made an average gross income of $1,069. But, if the 5% interest on the investment is deducted, or $588, the net earnings of each farmer are $481.

Up to this point, the farmer's income has been treated from the viewpoint of a landowner. However, we must not lose sight of the fact that 37% of all farmers in the United States are tenant farmers. So far as income is concerned, the farm tenant receives wages. He needs very little capital, since land and buildings make up nearly 90% of all farm capital, and these are supplied by the landlord. As a consequence, the tenant's income ought to be larger than the corresponding labor income of the landowner, if the former is to maintain an equivalent standard of living. As a matter of fact, it is larger. Among 153 tenant farmers in Lenawee County, Michigan, whose total capital invested amounted to $1,562 per capita, the total receipts were $1,111 and the average total expense $450. Hence, the gross income received was $661. But, allowing 5% interest on the investment, the average labor income was $583. However, considering the North Central States as a group, the average labor income of tenant farmers is about $700.

From the standpoint of a landlord, land is thought of as a given amount of capital bearing a current rate of interest. On the tenant farms mentioned above, the average investment of landlords was $12,218. The average total receipts were $856 and the average total expenses were $231. Thus, the average income of the landlord was $625, which represents a return of 5.11% on the investment. The average return throughout the states surveyed was from 3.5% to 8%.

Some eminent economists have written lately as if tenancy were a catastrophe and that our farming population was headed in that direction. As a matter of fact, however, tenancy represents progress almost everywhere it exists in the United States, and while the percentage of tenancy has been increasing, it is significant to note that the increase has been at a diminishing rate.

For practical purposes, one method of calculating the farmer's income is to compare it with the incomes of other classes. According to the last census figures, the average income received by all ministers in the United States was $663; that of lawyers, $682. Despite the tendency to increase the salaries of teachers, the average income of the latter in 1913 was less than $700. Thus.

we may conclude that farmers, on the average, are much more fortunate than either of the professions named.

Furthermore, the farming population may be compared with the manufacturing population. The latter is composed of three elements, namely, proprietors (3.6), managers and salaried employes (10.2), and wage-earners (86.2). On the other hand, farmers include farm owners or part-owners (49.2) and farm laborers (51.8). It is obvious that a much larger percentage of the farming population than the manufacturing population consists of proprietors and managers, and hence, farming offers the surer probability of success. Statistics of the profits of those engaged in manufacturing are not available, and technically the farmer belongs to the group of enterprisers, and his income ought to be compared with the incomes of the latter. But it is sufficient for our purpose to compare the incomes of salaried employees and laborers with the farmer's. The best salaried employees in manufacturing receive from $1,000 to $1,500 per year; the average per man is $1,187. Wage-earners receive an average income of $517.

The average income of the farmer, thus, compares favorably with the average income of the laborer, and this comparison is by no means insignificant, since the average income of the farmer in the United States is composed primarily of wages. Furthermore, the average income of good farmers compares favorably with that of the best salaried employees. Undoubtedly also, the incomes of farmers who have unusual capacities, foresight, etc., are larger, and consequently the margin of profits of such farmers would also be large. Probably, the incomes received by our best farm proprietors and farm managers would compare not unfavorably with the incomes of the corresponding persons in manufacturing. But the income of the farm laborer does not compare so favorably with that of the industrial laborer. The average wage of the farm laborer, not including board, was $330. However, during the last few years, the scarcity of farm labor coupled with the increased demand for it have resulted in a considerable increase in farm wages throughout the country. This means not only that the wage of the farm laborer has increased, but also that the incomes of those farmers who depend primarily upon a wage income have increased correspondingly.

Obviously, the incomes represented by interest and profits are the most variable. The amount of interest a farmer receives depends upon the amount of capital invested. Likewise, the amount of profits received by the farmer, as in any other business, will depend upon his capacity to perform the function of entrepreneurship. On the other hand, there is a general tendency toward the equalization of labor incomes in all parts of the United States. Consequently, in the long run, we cannot expect any general increase in the farmer's net income through an increase in wages. It must come primarily through the two other sources, either in the form of interest or profits. In

the corn-belt states, considerable capital in the form of land, buildings, live stock, machinery, etc., is invested in the farm enterprise, and the income received is looked at as so much interest on the investment. In fact there are many instances where farmers are receiving no labor incomes as such, but yet are able to thrive from the interest on their investments. The same thing is true, more or less, with respect to fruit-growing, cattle-raising, dairying, and in all industries where much capital is required to be invested in the enterprise. Interest, thus, forms the major portion of the incomes of those who are so engaged.

The farm entrepreneur does more managing than the entrepreneurs of other industries. This is due largely to the peculiarities of the farm enterprise. It is by no means so easy for the farmer to substitute some other person's services for his own managerial services as in the corporate form of industry. Of course, there are cases where hired managers do operate farms in the West, but it is the exception rather than the rule. Hence, profits in farming, generally considered, are almost indistinguishable from wages of management. But, precisely considered, pure profits, profits embodying the element of risk-taking, ought to be distinguished from profits embodying management. Theoretically, the two concepts are quite distinct. Technically speaking, many farmers do not receive pure profits; they receive wages for labor, wages for management, and interest on capital. However, not a few do receive pure profits as a reward for assuming the responsibility of the farm enterprise.

The chief incalculable element involved in risk-taking in connection with the farm enterprise is the probability of a rise or fall in the price of land. An increase in the value of farm land makes possible a surplus, which is profit. During the last decade, farm land has increased in value more rapidly than any other kind of farm property. The prices of farm products have also shown a marked increase in comparison with the prices of other products, and the influence is reflected in the value of farm lands. It is not unnatural, therefore, to expect that a considerable surplus, representing profits, has been due to a rise in land values, and this has gone to those who own lands. Where the landlord and the manager are distinct and separate agents in agricultural production, the former receives the benefit resulting from increased land values, and, in general, the landowner is entitled to this surplus as a reward for the risks incurred.

By way of summary, therefore, we come to the following conclusions: First, the average net earnings of farmers in the United States in 1909 were between $400 and $500. At the present time, it is conservatively estimated that the average farm income has increased by from 25% to 50%.

Second, in general, the average farm income compares favorably with the average income of almost any group of wage-earners or salaried employees.

We cannot make any direct comparison between the amount of profits received by the industrial entrepreneur and the farm entrepreneur. However, it is probably safe to conclude that the margin of profits is greater in the former case, while, at the same time, the percentage of failures is higher. In general, the latter affords the greater opportunity of fair success, although the profit is much less on the average.

Third, the incomes of tenant farmers are on the increase, and in general, the wages they receive correspond roughly to the gross income received by the farm owner. Furthermore, the wages of farm laborers are increasing for reasons already given.

Lastly, from a theoretical standpoint, the average gross income received by farmers in the United States consists primarily of a remuneration composed of wages of labor and wages of management plus interest on the investment. Deducting the small sum representing the interest on the investment, the net income is primarily a labor income. However, in cases where the functions of management and risk-taking are distinctly separated, and in instances where there has been a rapid increase in land values, the element of pure profits becomes more noticeable.

Thus, the tendency during the last few years has been by no means unfavorable to the farmer, but on the other hand, it has been decidedly favorable, especially during the recent war. There is no doubt that there were many farmers who were receiving excessive profits, perhaps more in proportion to numbers than those engaged in other industries—that is, as a class, farmers were receiving excessive profits more generally than any other single class. However, this is no condemnation of excessive profits. In general, they are justifiable as a reward for unusual risks and abnormal responsibilities. The point to be made is that the lot of the farmer is improving and that profits are becoming a more important element in the farm income.

University of Michigan.

PSYCHOLOGY.

INDIVIDUAL DIFFERENCES IN IMAGERY.

CHAS. H. GRIFFITTS.

An historical survey of the literature dealing with this topic reveals three separate lines of investigation. The first begins with the work of Fechner, who described the visual imagery of several persons, was carried further by Galton, and later by others who used modifications of Galton's questionnaire. These investigations have covered but one phase of the problem, which is that of the individual differences to be found in the clearness of "concrete" imagery.

The second line deals with the quantitative aspect of "concrete" imagery. It began with the work of Ribot and Dugas, who determined the kinds of images aroused by lists of selected words. More of this work has been carried on in Germany than elsewhere.

The third is concerned with the quantitative aspect of "verbal" imagery. It began with the observations of Charcot, and with the controversy between Stricker and Egger, with regard to the relative importance of the auditory and kinaesthetic elements in inner-speech.

From about 1880 to about 1910 it was generally uncritically assumed that the person who was found to be "visual" in one connection would also be "visual" in each of the other two. But about 1910 it began to be recognized that with the great majority of persons the concrete imagery is predominantly visual, and the verbal predominantly inner-speech (auditory-motor). This fact, along with the inability to find examples of the supposed "pure" types, brought this "pure type" period to a close.

Although it was noticed that visual imagery predominates in concrete imagery and inner-speech in verbal imagery, the exact relation between the two has never been determined. It may be that those with the greatest per cent of visual imagery in the first will also have more than the average in the second, even though it ranks second to inner-speech in the latter.

Nor has the relation between the qualitative and the quantitative aspects (that is, between clearness and frequency) been determined. A positive correlation has been generally assumed, but exceptions have been reported. At the present time, therefore, the three separate lines of investigation have never been brought together in a way that enables us to determine what the interrelations between them may be. It was my purpose to do this in order to determine the nature and extent of individual differences in imagery and the

possibility of adequately expressing them by any classification into types. This would give data bearing on Thorndike's contention that we have either but one type, or as many types as individuals.

The tests used will be described in detail in a later publication. They were arranged to give numerical scores for each kind of imagery for each individual.

Test A, for the clearness of concrete imagery, is a modification of the Galton questionnaire, with a different method of scoring, in that each image was compared not to the clearness of a percept of the object (which is impossible in most cases), but to the clearest images of the series. This involves a partial application of the order-of-merit method, which tends to eliminate the tendency of some subjects to overestimate all their images.

Test B, for dominance of concrete imagery, is a modification of what Titchener calls the Secor method, which gives scores in terms of percentage. This was modified so that the scores represent the actual dominance in attention of the different kinds of imagery instead of the mere frequency of each kind. When more than one kind of imagery was aroused, the subject was asked to state the relative importance or dominance of the two by a proportionate "distribution of seven points." The number of points given to each kind of imagery was reduced to percentages of the total number of points for all kinds. Seventy-five words and forty sentences were used.

Test C, for dominance of verbal imagery, also gives percentage scores. The verbal imagery in memory of both orally and visually presented material, of poetry, in writing, silent reading, etc., was used as a basis for the "distribution of seven points." It was found best to ask the subject to make a first division into visual (verbal) and inner-speech, and a second division of the inner-speech into its auditory and kinaesthetic elements, making a distribution of seven points in each case. From these values scores for visual, auditory and kinaesthetic verbal imagery were computed.

Test D is a visualization test, the scores being the number of seconds required to successfully answer a series of problems including the well-known "three-inch-cube" problems.

Test E is an objective test for the detection of inner-speech, and particularly of the auditory element, in verbal imagery. Lists of six letters and digits were read to the subject, who repeated them in reverse order. Half of these lists contained several like-sounding letters, the other half contained none. These are called "L" and "U" lists. The score, or the "U-L" is the sum of the differences in time and in accuracy of reproduction between the two kinds of lists.

One hundred and twelve subjects who were beginning students in psychology were tested.

Results.

Great individual differences were found in each test. The greatest variability was found for kinaesthetic imagery, the least for visual. None of the curves of distribution are multi-modal. In each of the tests for concrete imagery visual ranks first for the group, auditory second and kinaesthetic a poor third. In verbal imagery inner-speech ranks higher than visual (verbal), but when this inner-speech is split up into its two components, visual ranks first, auditory second, and kinaesthetic third. The tests used probably tend to over-emphasize the visual-verbal imagery.

There is some correlation between tests A or B and C, and a fairly high correlation between tests B and C. The person who ranks high in visual imagery in test B will likely rank high in visual imagery in test C, even though it is subordinate to inner-speech in the latter. There is a fair correlation between clearness and dominance, although there are marked exceptions.

No person was found who is limited to a single kind of imagery, nor was any found to be wholly lacking in any one kind. Nor is there any evidence of the existence of distinct combination-types, that is, of specific varieties of "mixed" types.

Both intra and inter-test correlations show clearly that there is a fairly high positive correlation between the clearness of auditory and visual imagery. Those persons who have little but visual imagery have a lower grade of visual imagery than those with clear auditory imagery.

Kinaesthetic imagery is shown to be a greater predisposing factor than auditory toward the use of inner-speech. In every case inner-speech correlates higher with kinaesthetic than with auditory imagery.

The correlations indicate the validity of the "U-L" test for the detection of auditory-verbal imagery.

University of Michigan.

A STUDY OF THE RELATIVE INFLUENCES OF ABILITY AND TRAINING ON PERFORMANCE.

SAMUEL RENSHAW.

There is a somewhat widespread notion that education or training tends strongly to eliminate inherited variations and to bring all persons to a single approximate level of achievement capacity. This paper reports a study of the nature and extent of the influence of twelve years' training on the performances of a group of sixty men students in a S. A. T. C. unit, whose chronological ages, training, health, social status, etc., were in close approximation. The group is thus a selected one, as selections go, and one should expect to find little variation in abilities or performance. Especially is this true if ability is demanded to attain high school graduation and admission to institutions of collegiate rank.

Studies of the use of differentiating mental tests with college freshmen are reported by Whipple, Yoakum, Bell, Waugh, Wissler, Sunne, Cattell and Farrand, Simpson, Uhl, Calfee, Tolman, Rugg, McCall, Thorndike and others. Many divergent varieties of tests were employed in these studies. Most of them deal with correlations of test ranks or scores with semester marks, achievement in certain collegiate subjects, etc. Since the experiences with psychometry in the army, attention is being redirected to studies of this type and efforts are being renewed and extended. Columbia University is reported to be about to make certain selected groups of tests a weighty factor in her requirements for matriculation. Yerkes, in a recently published paper, asks for the early grouping of all pupils in the public elementary schools into three types, represented by A, B and C abilities and the reshaping of the course of study, distribution of time, etc., to meet these specific abilities or disabilities.

From all this one may infer that there is a strong tendency away from devices, refinemens of technique and of content in human training and an equally positive movement toward the other pole—inherited potentialities—which things have been pointed out by the biologists as the real, essential and almost immutable differentia.

"In the present paper the term *ability* is made to include the sum-total of determining tendencies which in the face of a fixed group of stimuli resolve themselves into new, rapid and adequately adaptive (not in the Darwinian sense) action-systems according to the laws of recency and frequency. (Frequency being considered as possessing by all odds the greater weight). The subjects who have *ability* are distinguished from those designated by the term

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training principally in the respect of their lower synaptical resistence-thresholds. They are the quicker, better learners, so gifted in inheritance. This achievement-capacity is regarded as only slightly, if at all, influenceable by training."

The sixty subjects were members of a non-commissioned officers' training school, from which number ten were to be selected for officer training. The problem was to select, by means of tests, the men of greatest ability; to keep secret these names and after the official selections were made to compare test findings with Officer's judgments; and to determine the nature and extent of variations in abilities in subjects whose ages, health, training and social status was approximately the same. For, if the same wide ranges of differences exist after twelve years of scholastic experience, one is forced to conclude that this training has had little or no influence in equalization of chances for success.

Assisted by his colleague, Professor T. S. Henry, the writer gave six group tests to the sixty men. The tests employed were selected because of their known high correlation with general intelligence and because they are said to measure traits essential in the officer's make-up. These were:

1. The Franz Rectangular Maze (No. 75,224).
2. Woodworth and Wells' Hard Directions.
3. Opposites. Whipple's adaptation of Simpson's list.
4. Analogies. Whipple's List C.
5. Substitution. The Digit-Symbol Test.
6. Completion. Trabue Language Completion, Scale J.

Securing a control group of illiterates of the same ages and opportunities was not only impossible but was also regarded as unnecessary.

The tests were given and scored in the ways of accepted usage. Test conditions were of the very best, as reported by both subjects and examiners. Two minutes on the first five and five minutes on the last test were allowed. The subjects were then ranked according to scores in each test and these ranks were then amalgamated as the final rank. By the Spearman "foot-rule" method the following correlations of the tests with final ranks were obtained:

Analogies	.81
Opposites	.71
Substitution	.71
Directions	.66
Completion	.64
Maze	.40

The tests were found to be more reliable in the selection of men of ability than the combined judgments of the Officers. The sixty men's scores, arrayed in a histogram, show practically the true Galton ogive. This means that the selections from the total group made by the officers was a pure one-to-one chance picking, and as to the final selections of the best ten the tests gave a more reliable sifting in the 15 minutes actual working time than the officers got from their 72 days of observational study of the behavior of the men.

One must conclude from this wide distribution of abilities that education in the grades and high school has done little or nothing to eliminate differences of performance capacity. It begins to look increasingly like performance or achievement is, in its last analysis, a function of a certain configuration of abilities, which are inbred and which are influenced but slightly if at all by education and training. If this be true it is bound to have a far-reaching effect upon the future of training in colleges and universities.

The same group of tests applied to over one hundred members of a Rotary Club and to fifty mature women school teachers in a certain city showed the same wide ranges of abilities. Lack of space prevents showing the figures and tables.

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SOME PSYCHOLOGICAL PROBLEMS IN THE RECONSTRUCTION OF EDUCATION.

GILBERT L. BROWN.

As an introduction to this paper, I wish to point out and emphasize the desirability of psychologists recognizing as legitimate parts of their work the many comparatively new fields which are demanding assistance from psychology. Business men—especially salesmen and advertisers—are demanding to know the psychology of successful business. Men interested in law or medicine are talking freely of the psychology of the witness and the juror, or of the patient. Sociologists are at present greatly interested in the psychology of social action. And, what is more important than any of these, the educator is demanding to know the psychology of his work.

If we now turn to inquire what psychologists—I mean leading psychologists—are doing in response to these appeals, we find that they are not, generally speaking, giving them very sympathetic consideration. As one result of this attitude, business men, attorneys, physicians, sociologists, and students of education are attempting to set forth the psychological principles underlying the work in which they are engaged. Most of these men know very little psychology, and accordingly their attempts are not infrequently extremely naive. But these writers are not wholly to blame for their superficial psychology; the fault lies rather with psychologists themselves who refuse to admit the applications of psychology or the specific problems of business and professional men to the sanctity of their thought-world. I do not mean by these remarks to disparage in any way the study and teaching of "pure" psychology, but to point out the need for making psychology more comprehensive in scope.

At the present time education is undergoing very radical changes. Much of the old in content and method is proving ineffective and is being discarded; acordingly there must follow a period of reconstruction. In fact we are already within such a period. Certain phases of this reconstruction involves distinctly psychological problems, and must depend very largely upon the work of psychologists for the solution of the problems.

Education needs to know the nature of mental processes, as set forth in general psychology; but it has certain specific psychological problems which must be solved.

One of the newer fields of education—and psychology—is the subject of intelligence. In fact the study of intelligence is forcing a revolution in the classification of pupils. We have for centuries guessed and speculated as to

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the reason why two pupils of the same age do not progress in school at equal rates. The reason has commonly been ascribed either to stupidity or to the work of the devil. But thanks to modern psychology, we now see that the difference is, in large measure, the result of difference in intelligence. Last year in the examination of over two hundred school children, I found that in no grade was there a range in the intelligence of the pupils of less than three years, and in some cases the range was five years.

It is at this point that a new and important problem arises in education, which psychology must solve. Some educators maintain that if a pupil is one or several years older mentally than others of his chronological age and school grade, he should simply be given some additional work and kept in the same grade; others maintain that such a pupil should be rapidly advanced until he reaches a grade of his own intellectual level, regardless of the chronological age of the pupils of that grade. Now, this educational problem presents three psychological problems: First, Does the mind of the bright pupil grasp ideas and thoughts differently from the way that the slow pupil does? If so, how? Or, putting the question somewhat more specifically, Just wherein is the difference between pupils whose mental ages are 8 and 12, 10 and 15, and so on? Second, What is the effect upon the child's mental development of keeping him in the same grade with those who are decidedly below him in mental age? That is, does he become intellectually lazy and indifferent, or does he remain just as keen and progressive as though he moved along as rapidly as his capacities would permit? Third, What is the effect upon the slow pupil of advancing him beyond the standard of work adapted to his intelligence? Does it tend to strengthen him intellectually, or does the failure which frequently results discourage him and lead him to cease putting forth effort? Education may, of course, discover the answer to these questions, if given sufficient time; but we need *at once* a careful psychological investigation of the problems and a statement of the underlying principles.

The ultimate aims of education must be determined very largely from the point of view of sociology, but the character of work that a child can pursue profitably at a given point in his development must be determined by psychology. Accordingly, the psychological problem which arises out of this educational question pertains to the relative strength—I use "strength" for want of a better term—of the mental capacities at different mental ages. Much of the effectiveness of education depends upon our knowledge of this problem. There is a common belief that children's imaginations are more active than those of adults; that their memories are superior both in regard to ease of learning and retentiveness; and that children possess only little ability to think before the age of 14 or 15. These beliefs influence the whole character of elementary education. An examination of the content and method of elementary education will show that the chief emphasis is placed upon memory and imagina-

tion, and that thought occupies a relatively insignificant position. Judd has suggested—and his suggestion seems well founded—that children are not more imaginative than adults, but that their constructions are simply less controlled and consequently are more likely to attract our attention. If this position be correct, then much that the school teaches younger children is clearly without psychological foundation.

A small amount of investigation of a scientific character has been done on the subject of memory. Meumann found by having persons memorize non-sense syllables, that, for the ages of 7, 14, and 22, respectively, the abilities were in the ratio 3, 8, and 12. I recently enlarged upon Meumann's experiment by employing in addition to non-sense syllables, sense syllables and poetry. I employed the last two kinds of material to determine whether or not there existed a difference between memorizing non-sense syllables and other materials. My results with non-sense syllables were almost identical with those obtained by Meumann, and the results of memorizing sense syllables and poetry differed so little from these that they may be considered the same. The ratios of abilities in the three ages for the three kinds of material were as follows:

Age.	P.[1]	S.S.[2]	N.S.[3]
20	4	4	5
14	2	2.5	3
7	1	1	1

If these experiments may be taken as an index of relative memory abilities, it is readily seen that the child's memories are decidedly inferior in quickness of learning to those of the adult.

The question of relative retentivity has not been so satisfactorily studied. I repeated my experiments—as described above—60 days after the material was first learned, and found that the ratios for relearning were approximately 1, 2, and 4 for the various groups of subjects. That is to say, the ratios of retentivity were not materially different from those of the first learning, and suggests strongly that children's memories are not superior to adult's in this respect, but, on the other hand, that they are much inferior. It should be remarked in passing that in obtaining my experimental results fifty pupils of each age were examined. The failure to obtain better results on retentivity was owing to the extreme difficulty in preventing children from repeating the material between the first learning and the relearning.

In regard to the ability of children to think, we have little definite knowledge. Although no one doubts that they do think to some extent, there is no agreement as to their real ability. At one extreme it is maintained that their ability is almost zero, while at the other it is asserted that it is almost equal to that of the adult. Until this question is scientifically settled, it is impos-

[1]Poetry. [2]Sense syllables. [3]Nonsense syllables.

sible to determine what part the element of thought should play in elementary education.

A third educational problem-centers around imagination; this is quite distinct from the question in imagination suggested above. (I am employing the term "imagination" only in the constructive sense). In the school world. imagination or imaginative is commonly associated with fancy, and accordingly a great amount of non-factual material of almost every description is used to train "the imagination." In fact much that is taught in literature and pseudo-literature is justified upon this ground. When we go to text-books in psychology we find very little material of any assistance on this point. About the only contribution to the solution of this problem, insofar as I am aware, appears in the revised edition of Judd's "Psychology." The author gives us a classification of imaginations which seems invaluable in dealing with this problem. He distinguishes three kinds of imagination—scientific, literary, and fancy. The acceptance of these distinctions would enable the school to reorganize its material in a very different way from what it is at present. A much greater amount of scientific material and human experience would take the place of the excessive amount of what contributes chiefly to the building up of fancy. But until psychology recognizes generally these distinctions, or others of at least equal value, we shall find progress difficult.

A fourth problem in education pertains to the doctrine of recapitulation and the culture epoch theory—the theory that the child is by nature successively savage, barbarian, half-civilized, and civilized. If this theory is accepted, then education must be based on these stages; and this is actually found to be the situation in a large percentage of the schools today. Children are taught Indian, Arabian, and Hebrew stories, Greek and Roman myths, and various modern stories of adventure because the pupils are believed to be in certain psychological stages. The practice is based on the biogenetic "law," which is not a law at all but only a vaguely supported theory. The problem is in reality a psycho-biological one, and demands a careful examination of the doctrines and facts of evolution. Present-day knowledge and theory of evolution fail to support the biogenetic "law." Evolution, as T. H. Morgan points out, does not take place by new characters adding themselves "to the end of a line of already existing characters but, if they affect the adult characters, they change them without, as it were, passing through and beyond them." To use the classical example of the gill slits, these slits are not to be interpreted as the remnants of an early adult fish stage, but of a primitive embryonic stage or condition. That is, the human embryo does not repeat an ancient adult form, but only an embryonic one. Likewise, the child of six is not repeating the adult life of earlier man, but only the child life of our ancestors. Thorndike has investigated this problem somewhat from the purely psychological side, and concludes that there are no such stages or periods as commonly described. Yerkes suggests that we imagine the stages then believe

that they exist. However, we need further study of an exact character on the psychological as well as the biological side of the problem.

An old psychological problem continues to disturb education, and, although psychology has rendered some assistance, it has not given the light on the subject that is needed. The problem is that of general versus specific training. Will the study of arithmetic enable a person to reason on every subject; will the study of non-factual stories train a child to construct images of a scientific character; will learning poetry train one to memorize faces; and so on? Probably no other one thing has been so influential in determining the curricula of schools as the assumption that the doctrine of general training is sound. Our educational journals are at times literally filled with speculations on this problem, but we are getting very little scientific psychology that aids us in settling this question. A few psychological attempts have been made to obtain facts, but many of the studies have been made by amateurs and the results have been accordingly amateurish, and have settled nothing. The correct answer to this problem means almost everything to education, since if there is a high degree of general training the curricula need be relatively simple, but if there is specific training chiefly, then curricula must from necessity be relatively complex.

Another problem in education,—the last one which I shall mention,—is that of teaching how to study. One phase of this problem is psychological, and involves a knowledge of the laws of mental action. It is very easy to assign a rule, a definition or a poem to be memorized, but it is a very different matter to explain to the learner how to memorize it economically. To do this, we must know the laws of memory, such as Professor Pillsbury gives in his "Essentials of Psychology." But text-books in psychology seldom state these laws. Again, we assign a problem and instruct the pupil—or the student, for that matter—to "think it out;" but it is the exception and not the rule that we find young people who know what thought is, and who know any laws to guide them in thinking. The latter difficulty lies chiefly in the fact that such laws have not yet been stated from the point of view of psychology. Accordingly, until psychology states definitely and clearly the laws of mental action or the conditions of such action, the educator cannot teach pupils how to employ these processes effectively in study.

In conclusion, it is evident to students of educational theory and practice that further advancement in this field depends very largely upon the work of psychology in discovering laws and conditions of mental development and mental action. But psychology must do more than this: it must state these laws and conditions in clear, non-technical language, and must see to it that the knowledge is widely disseminated. Psychologists should follow the advice of Huxley and publish their discoveries in an attractive, readable form, so as to make their science exert the greatest possible influence.

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LOCATION OF THE SENSATION OF MOVEMENT.

Z. PAULINE BUCK.

Due to the fact that there was some controversy as to the origin of the sensation of movement and in answer to the question whether one is conscious of the position of a member on the basis of muscle sense only, the following experiment was undertaken in the latter half of the school year 1915-1916. The problem was carried out according to the suggestion of Doctor J. F. Shepard. The experimental work was done in the Psychological Laboratory of the University of Michigan. The aim was to see if the tongue, a member controlled entirely by muscle, could be trained to move in a definite direction at will, all supplementary sensations such as contact and vision being ruled out.

For this purpose apparatus was constructed which would hold the subject's head in a stationary position and at the same time, by clamping over the lower and upper teeth hold the mouth wide open. A tongue pen was so constructed as to automatically vary in length as the writing surface was nearer or farther from the subject due to the tongue describing an arc rather than a straight line. Two clamp standards held a rectangle of celluloid upon which was drawn a vertical line. This was placed before the subject so that by projecting the tongue he could comfortably reach both bottom and top of the line. Behind the rectangle was a mirror so that the subject could see the position of the tongue in practice work.

The subject was allowed to draw the tongue from the bottom to the top of this line three times, then the mirror and celluloid were moved away and a kymograph with smoked paper drawn up. Upon this the subject tried to reproduce the line practiced on the rectangle. Six trials were given each day, each preceded by three practice drawings. The experiment was carried out at regular intervals. When the subject reached a fair degree of perfection he was given a horizontal line to draw. Five subjects were used. At the close of each day's series the subject was asked to write an introspection and to draw a series of six vertical lines as a basis of comparison of the steadiness of the subject.

A comparison of the records made by each subject at the beginning of the experiment and those made at the close, shows a very evident improvement in the character of the lines. The introspections were also of interest although not uniform in substantiating the muscle sense of definite position. The introspection in this respect differ in the same subject from day to day. They overbalance very definitely, however, in the direction of consciousness of tongue

position. According to the introspection the subjects were conscious of marked deviation but could not detect slight movement.

Now, studying the introspections from the point of view of consciousness of movement regardless of its interpretation by the subject, we find a much greater uniformity of opinion. The great majority of introspections mention sensation of movement and only one subject on one day definitely states that there was no such sensation.

To sum up our results we find that there is a marked improvement in the control of the tongue with practice and that in practically all cases for all subjects there is a sensation of movement experienced. In the majority of cases the sensation has been interpreted by the subject to properly portray the line drawn. This we believe to be, especially when taken with anatomical findings, a proof that sensation of movement arises from the muscle.

Lapeer, Michigan.

MEMORY AS AFFECTED BY CLIMAX AND ANTICLIMAX ARRANGEMENT OF MATERIAL.

BY HENRY F. ADAMS.

Previous investigations by many men have shown that the memory efficiency of size of advertisements can be shown by a curve which has a simple mathematical formula. The memory efficiency of duplication and variation have likewise been determined and the formulae of the curves plotted from the results are equally simple. The ratios are given in the following table:

	Units of stimulation.			Efficiency
	1	2	4	
Size........................	1.00	1.62	2.57	1.45 root
Duplication.................	1.00	1.51	2.20	1.70 root
Variation...................	1.00	2.33	4.13	Almost directly.

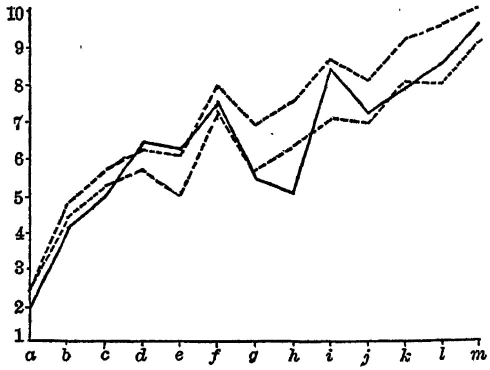
If these are really fixed laws of memory, it ought to be possible to predict the results obtained from memory experiments in which mixed sizes of advertisements are used. For instance, by careful search through a number of mediums, we can obtain a full page, a half page and two quarter page advertisements of the same commodity, and sufficient other combinations of different sizes to make a dummy. Such a dummy was prepared and while the experimental work was going on, I determined the values to be expected as a result of the different combinations of sizes of advertisements. This was done by combining the tables for size and variations as given in the following table:

Size	Frequency of Presentation.			
	1	2	3	4
⅓........................	1.00	2.33	3.30	4.13
½........................	1.62	3.78	5.35	6.70
1........................	2.57	6.00	8.48	10.60

Size	Appearance Number			
	1	2	3	4
¼........................	1.00	1.33	0.97	0.83
¼........................	1.62	2.16	1.57	1.35
1........................	2.57	3.43	2.48	2.12

21st Mich. Acad. Sci. Rept., 1919.

The computation pointed out a fact which should have been foreseen, but was not, viz.: that the order in which the mixed size of advertisements were seen by the subject exerted an influence upon the memorability of the advertisement. The dummy already mentioned had not been prepared to take account of this feature, so in giving the results, three curves were prepared, showing the obtained results and the maximum and minimum theoretical results. This graph is appended:



COMPARISON OF MEMORY EFFICIENCIES.

FIG. 2. Solid line: experimental results. Dotted line: maximum and minimum theoretical results.

a = 1 full,	*g* = 1 full—1 half—2 quarter,
b = 1 half—3 quarter,	*h* = 1 full—2 half—1 quarter,
c = 2 half—2 quarter,	*i* = 2 full—1 half—1 quarter
d = 3 half—1 quarter,	*j* = 2 full—2 quarter,
e = 1 full—3 uparter,	*k* = 2 full—2 half,
f = 1 full—3 half,	*l* = 3 full—1 quarter,

m = 3 full—1 half.

It is obvious that if the idea in mind is a condition of attention, that a large advertisement appearing first should create a more vivid idea than a smaller one and hence should prepare the mind better for the following advertisements of the same commodity. In our theoretical curves, this factor was given an arbitrary value of 10%. To determine the actual value, three dummies were prepared, all made up on the same general plan. In each dummy, four firms advertised with each of the mixed sizes which were possible by a combination of full, half and quarter pages, a total of twelve combinations. In each case, half of the firms showed their largest advertisements first, followed by the smaller sizes, and in the other half the smaller advertisements appeared first, followed by the larger. Alternate subjects began the reading with the first page and the last page of the dummy respectively. Approximately 500 subjects were used. The results follow in tabular form:

Sizes of Advertisements.	Anticlimax.	Climax.
3 F— 1 H.	119.0	100.0
3 F— 1 Q.	88.6	100.0
2 F— 2 H.	93.0	100.0
2 F— 2 Q.	133.0	100.0
2 F— 1 H— 1 Q.	106.0	100.0
1 F— 3 H.	100.0	100.0
1 F— 3 Q.	126.5	100.0
1 F— 2 H— 1 Q.	124.6	100.0
1 F— 1 H— 2 Q.	121.5	100.0
3 H— 1 Q.	125.0	100.0
2 H— 2 Q.	91.3	100.0
1 H— 3 Q.	127.5	100.0
	112.99	100.0

This table demonstrates fairly conclusively that the anticlimax order of presentation is 13% more effective than the climax. It further indicates that the assumed 10% of added attention value resulting from the primary larger advertisements is about the correct figure. It may be pointed out in conclusion that this result indicates an interesting difference between art and science, for in one case climax is desirable, in the other it results in a loss of efficiency.

University of Michigan.

INSTINCTS AND SOCIAL IDEALS IN HUMAN ACTIVITY.

W. B. PILLSBURY.

(Abstract.)

In much of current discussion one sees confusion between instinct and other factors that have the same compelling force, but evidently cannot be remnants of useful early responses. If we recognize that in every man there is an instinct which compels him to accept the opinions and standards of others and that this instinct gives the convention or ideal much of the compelling force of instinct, we may reconcile the difficulties. This instinct exhibits itself as bashfulness in the youth, as fear when one faces a crowd and as respect for the accepted opinions of society in all individuals and places. It is at the basis of imitation, of such reactions as keeping clean, of respect for laws, moral and legal. One could probably find in it an explanation of much of what is popularly called conscience. In each case the content of the act or tradition or ideal is given by habit or custom, or even by reason, but the force which compels its acceptance is this general instinct. Acceptance of this view makes it possible to explain the force of the tendency to perform certain acts, and at the same time the variation in these apparently fundamental human characteristics from society to society, and from age to age.

University of Michigan.

AN ACCOUNT OF SOME OBSERVATION TESTS AND OF A NEW STEREOSCOPE.

BY JOHN F. SHEPARD.

(Abstract.)

In the tests to be used for observers in the aviation service, the individual was given a photograph of a large and varied landscape and allowed to study it twenty minutes. Of several tests tried, two which seemed to show significant individual differences were retained for use. In the first, the subject was shown for two seconds a detached piece of the picture, either on the same scale as the original, or enlarged, or reduced, and on which either one or two crosses were marked. The subject's problem was to grasp the crosses in relation to familiar landmarks, and, after the exposure, to refer to the original and record the location of the crosses accurately with reference to coordinates. The results were graded by counting 10 as perfect and deducting one point for each eighth of an inch of error. This was based upon a plot of distribution of errors which showed localizations with errors greater than about one inch to practically pure guess. Sixteen pieces were shown in the test. In the second test, the subject was shown a picture of the same character and size as the original, of the same landscape except that it might be modified at as many as six places. The modification was done by retouching with pencil or KCN solution as needed. Any objects might be added or deleted and replaced by other conditions. The subject's problem was to detect and grasp accurately any changes from the original. The original was not in sight during this exposure. After the exposure the subject referred again to the original and recorded the location and concise description of all changes he was able to detect. Sixteen modified forms were shown in the test. Both tests showed marked individual differences, but depend upon partly different factors, and, though there is a strong correlation, a man's rank in the one is not necessarily the same as his rank in the other.

The stereoscope is a modification of the Wheatstone instrument with the addition of appropriate convex lenses to be worn by the operator and arranged to mount simultaneously in the field of fixation two pairs of large airplane stereoscopic photographs. This gives a larger view than the Brewster and makes possible advantageous comparison of two views of the same region. The instrument allows independent adjustment of the different pictures. The lenses compensate for the lack of convexity of the lenses of the eyes with accommodation for distant vision, and thus give a clear view and excellent perspective. It was in this especially that the Brewster excelled the older Wheatstone.

University of Michigan.

REPORT ON CORRELATIONS OF MENTAL FUNCTIONS.

BY E. C. ROWE.

(Abstract.)

The tests used in this investigation were a series of form boards based upon the Freeman board, a graduated series of absurdities and the Binet aussage test as given in Wripple's Manual.

The correlations are based upon the results obtained from 200 school children from the third to the ninth grade inclusive, 60 feeble-minded, 65 adult criminals, 32 truant boys, 20 wayward girls, and 14 praecox cases.

The correlations obtained indicate a low or zero correlation in most cases between performance and memory, between performance and judgment, between performance and mental age, but a significant correlation between memory and judgment, between memory and mental age, and between judgment and mental age.

Central Normal School, Ypsilanti, Michigan.

GEOLOGY AND GEOGRAPHY.

NOTES ON THE STRATIGRAPHY OF THE RACINE FORMATION OF THE NORTHERN PENINSULA OF MICHIGAN.[1]

G. M. EHLERS.

The use of the name Racine is suggested by the writer for the thick-bedded, white dolomite formation at the top of the Niagaran of the Northern Peninsula, which heretofore has been designated as Guelph and Engadine. Dr. A. C. Lane[2] in 1908 referred to the formation as Guelph, correlating it with the formation of that name in Ontario. In 1915, Mr. R. A. Smith[3] provisionally named the formation Engadine and indicated its probable correlation with the Guelph. In the following year, the name Engadine was accepted by the Michigan Geological and Biological Survey[4] and the formation definitely correlated with the Guelph. Recent studies by the writer indicate, however, that the Engadine dolomite includes strata which are older than Guelph as well as strata of Guelph age. The name Guelph, since it was not proposed to include these older strata, is therefore inappropriate for this formation. The Engadine formation, furthermore, is with little doubt continuous with the formation in eastern Wisconsin which was named Racine by Professor James Hall[5] in 1862. The name Engadine, since it is applied to a formation previously designated as Racine, should therefore be rejected.

The division of the Racine of Wisconsin into the Guelph and Racine by Professors Chamberlain and Whitfield is apparently unwarranted. These writers[6] applied the name Guelph to the uppermost strata of the Racine formation of this state, upon finding that they contained a fauna very similar to that of the Guelph formation of Ontario. They[7] retained the name Racine only for the lower strata of the formation, designated by that name by Professor Hall. When making this division, Professors Chamberlain and Whitfield[8] recognized that the Wisconsin Guelph and Racine, as used in their restricted sense, do not differ essentially in lithologic character and that numerous Guelph species are present in the Racine beds. In a communication to the writer, Dr. E. O. Ulrich of the United States Geological Survey states that, so far as he knows, there is no stratigraphic nor paleontologic break

[1]Published with the permission of the Director of the Michigan Geological and Biological Survey.
[2]Lane, A. C., Ann. Rept. for 1908, Michigan Geol. Survey, pp. 56-57.
[3]Smith, R. A., Pub. 21, Geol. Ser. 17, Michigan Geol. and Biol. Survey, pp. 150-151, 1915.
[4]Allen, R. C., Smith, R. A., and others, Geological Map of Michigan:—Pub. 23, Michigan Geol. and Biol. Survey, 1916.
[5]Hall, James, Report on the geological survey of the State of Wisconsin, Vol. 1, p. 67, 1862.
[6]Chamberlain, T. C. and Whitfield, R. P., Geology of Wisconsin, Vol. 2, pp. 335-336, 1878.
[7]Op. cit.
[8]Op. cit., p. 377 and faunal lists, pp. 384-389.

between the beds of these formations. Because such a break seems to be absent, Dr. Ulrich would not divide the formation designated Racine by Professor Hall. It is the writer's belief that most stratigraphers will agree with Dr. Ulrich that the division of the Racine of Wisconsin by Professors Chamberlain and Whitfield is unjustified.

There seems to be no better reason for dividing the Racine formation of the Northern Peninsula of Michigan than of Wisconsin. The strata throughout the formation in the Northern Peninsula are very similar in lithologic character and no evidence of a stratigraphic or paleontologic break seems to be present.

In the Northern Peninsula, the Racine formation is at or near the surface of much of the region adjoining the north shores of Lakes Michigan and Huron. It is exposed at many places on the shores of the Point Detour peninsula, Poverty and Big Summer Islands, Lake Michigan. The land adjacent to Lake Michigan between the Point Detour and Seul Choix Point peninsulas is probably underlain by older Niagaran strata of the Manistique formation, although parts of this land, especially the extremities of the more lakeward extended peninsulas, may be occupied by the Racine dolomite. A small outlier of the Racine dolomite occurs at the village of Whitedale, which is situated northwest of Seul Choix Point on the Minneapolis, St. Paul and Sault Ste. Marie Railroad. Most of the Seul Choix peninsula is underlain by the Manistique strata, areas of Racine dolomite occurring only on its southwest and northeast sides. This local areal distribution is due to the erosion of the latter formation from the top of a low anticline, having a crest-line parallel to the northwest-southeast axis of the peninsula. A continuous belt of Racine dolomite, having an average width of six miles, extends from the Seul Choix Point peninsula to the Detour Passage and borders the north shores of Lakes Michigan and Huron except where it extends across the base of the large, triangular-shaped St. Ignace peninsula. The surface rocks of the St. Ignace peninsula and possibly the southern part of the St. Martin's Point peninsula belong to the Monroe-Salina group. The southern portion of the Point St. Vital peninsula is apparently underlain by the Manistique formation. A narrow strip of land, adjoining the shore of Lake Huron between this peninsula and the village of Detour on the Detour Passage, may also be underlain by the Manistique, although it seems more probable that it is underlain by the Racine dolomite. Outcrops of the latter formation are numerous along the south shore of Drummond Island. The presence of a few exposures of the underlying Manistique formation along this shore is apparently due to the erosion of the Racine dolomite from the tops of very low anticlines.

The Racine formation consists of very thick beds of hard, highly crystalline dolomite of a predominant white color. Some beds are bluish-white or very light-gray. Upon weathering, the color of the beds, especially the

bluish-white ones, changes to a light-buff or brown. Some strata are also characterized by many cavities, which are more or less completely lined with crystals of dolomite. The beds generally show a very poorly developed and irregular jointing. In the unweathered condition, the dolomite is usually massive, but upon weathering, it often shows numerous, more or less closely spaced and uneven planes of bedding.

The Racine formation in the Northern Peninsula is probably 275 to 300 feet thick and has a general dip southward of 40 to 60 feet per mile.

The Racine dolomite lies conformably upon the strata of the Manistique formation. The uppermost Manistique strata consist of thin, uneven-bedded, siliceous dolomites of a buff to brown color. They are also characterized by relatively few silicfied corals, such as *Favosites favosus*, *Halysites catenularia*, *Alveolites undosus* and *Cladopora laqueata*, which become very abundant in lower strata of the formation. At some localities, the contact between the two formations is well-defined; at others, it is more or less obscured by a few feet of transitional strata, which, in the writer's opinion, should be included in the Racine formation, because they are more nearly related in lithologic character to the Racine than to the Manistique strata.

So far as known, the contact between the Racine dolomite and the overlying strata of the Monroe-Salina group is not exposed. The lowest, observable strata of the Monroe-Saline group, which apparently are very near to this contact, outcrop on the bottom and sides of the Carp River in the S. E. ¼ Sec. 12, T. 42 N., R. 4 W., Mackinac County. These strata are composed of thin-bedded, fine-crystalline dolomites of light pinkish-gray and brownish-gray color.

The correlation of the Racine formation of Michigan with the Racine formation of Wisconsin is based chiefly upon the lithologic similarity and apparent continuity of the strata. This correlation is supported by the fact that the Racine formation occupies the same stratigraphic position in both states. In northeastern Wisconsin, the formation rests upon the Upper Coral Beds. In Michigan, it rests upon the same strata, which are included in the Manistique formation. The Racine formation, in both states, is overlain by Cayugan strata of similar lithologic character. Whether these beds are of exactly the same age in the two states is, however, not known.

The lowermost strata of the Racine formation of Michigan and northeastern Wisconsin and the massive, sparingly-fossiliferous beds of dolomite at the top of the Lockport formation of Cockburn and Manitoulin Islands, Ontario are lithologically similar and with little doubt continuous. The uppermost beds of the Lockport of the Ontario region southeast of Manitoulin Island may represent a further extension eastward of these same beds.

Certain information, communicated to the writer by Dr. M. Y. Williams of the Canadian Geological Survey, indicates that the uppermost strata of the Lockport of Dawson Point, Lake Timiskaming are lithologically similar to the

lowest beds of the Racine of Michigan. These widely separated rocks may occupy the same stratigraphic position.

The Guelph formation of Ontario, in the opinion of the writer, is to be correlated with certain strata composing the upper part of the Racine formation of Wisconsin and Michigan. This correlation is determined chiefly by the presence of Guelph fossils in the rocks of the three regions. As previously noted in the first part of this paper, numerous Guelph species were also found to be present in the lower strata of the Racine of Wisconsin (Racine beds, in the restricted sense) by Professors Chamberlain and Whitfield. A few Guelph species, *Favosites cf. occidens, Amplexus whitfieldi, Pycnostylus guelphensis, Poleumita cf. scamnata, cf. Pycnomphalus solarioides* and *Trimerella sp.*, have been collected by the writer from strata near and a short distance below the middle of the Racine formation in Michigan. The reason that a larger number of Guelph species have not been found in Michigan is, in the writer's opinion, due to the fact that most of the upper strata of the Racine formation, which would be likely to contain numerous Guelph species, are inaccessible, owing to a covering of glacial soils. Since the Guelph fossils may occur in the lowermost strata of the Racine of Wisconsin and Michigan, which are with little doubt of upper Lockport age, they do not afford a means of determining the number of feet of Racine strata in the two states that should be correlated with the Guelph beds of Ontario.

The Eramosa beds of Ontario may be a correlative of certain strata of the Racine formation.

It is not the purpose of this paper to indicate all the formations which may be correlated, wholly or in part, with the Racine of Michigan. Such stratigraphic relationships will be considered more extensively by the writer in a forthcoming paper upon the Niagaran deposits of the Northern Peninsula, which will be published by the Michigan Geological and Biological Survey.

It is necessary to note, however, that the Racine formation of Wisconsin and Michigan is closely related in age to the Leclaire limestone of Iowa. Professor Hall[a] stated that the Racine of Wisconsin " * may be considered indentical with the Leclaire limestone of Iowa, holding precisely the same geological position, and containing some similar if not identical fossils; * * *." In a communication to the writer, Dr. Ulrich states that there are various reasons for believing that the Leclaire and Racine formations are not exactly equivalent. In consideration of Dr. Ulrich's opinion, the names Leclaire and Racine should be employed for the formations in question. If Professor Hall's opinion regarding the equivalency of the two formations should be proven correct, the name Racine, for the uppermost Niagaran formation of Michigan and Wisconsin, would have to be rejected for the older name Leclaire.

Ann Arbor, Michigan, April, 1919.

[a]Hall, James, Report on the geological Survey of the State of Wisconsin, Vol. 1, p. 67, 1862.

GLACIAL AND GLACIAL LAKE FEATURES IN THE VICINITY OF KALAMAZOO.

FRANK LEVERETT.

(Abstract.)

The Kalamazoo Valley was covered by the icesheet down to the time of the Battle Creek moraine, and there was direct drainage southward to the St. Joseph River and thence past South Bend to the Kankakee River which drains to the Gulf of Mexico. The Lake Michigan ice-lobe then shrank back to the position of the Kalamazoo moraine and a lake developed in front of it immediately east of Kalamazoo which drained southward past Austin and Gourdneck lakes and the village of Vicksburg to Portage River and thence to the St. Joseph River at Three Rivers. It is proposed to call this Lake Kalamazoo because of its close relation to the site of the city. It stood at an altitude of about 870 feet, or 100 feet above the business portion of the city. It was, however, very shallow to the south of the valley and its bed carries only a small amount of lake silt. It was this lake that determined the abrupt eastern limit of the outwash plain of the Kalamazoo moraine in the district just south of Kalamazoo.

After forming the Kalamazoo moraine the ice-border made a stand immediately west of the moraine and caused ponding of water in the vicinity of Alamo at an altitude about 50 feet lower than that of Lake Kalamazoo, and this found southward discharge along the inner or west border of the Kalamazoo moraine to the St. Joseph River at Niles and thence southward to the Kankakee at South Bend. It is proposed to call this Lake Alamo.

With the recession of the ice-border to the position of the Valparaiso moraine the waters in front of the Lake Michigan ice-lobe became ponded in the vicinity of the Kalamazoo River at a level about 50 feet lower than Lake Alamo, or an altitude of 765 feet to 770 feet. A long lake was formed that extended from Gun Lake southward to Decatur where it opened into Dowagiac River, and this in turn entered another lake opposite Dowagiac which extended to the Kankakee River at South Bend. This ponded condition is known as Lake Dowagiac and has already been figured in Monograph LIII of the U. S. Geological Survey. This lake had well-defined shore lines on a considerable part of its border and evidently persisted for a period of some centuries at least.

When the Lake Michigan lobe was forming the system of moraines known as the Lake Border morainic system, which lies just outside the border of Lake Michigan, the Kalamazoo waters were ponded below Allegan to a height

sufficient to find discharge southward into Lake Chicago, which stood at a height of about 60 feet above the level of Lake Michigan, or 640 feet above sea level. With the recession of the ice from this morainic system the Kalamazoo River drained directly into Lake Chicago.

The paper took up a description of the moraines and other glacial features which have been referred to in this abstract, and brought out by means of maps the relation of the moraines to the ponded waters.

MAPPING THE UTILIZATION OF LAND.

[Abstract of Article published in the Geographical Review, New York.]

C. O. SAUER.

The principles of geographic mapping, properly so called, can hardly be said to be formulated. Geographic field work is still in its beginnings, and the geographic survey is not even projected. The true geographic map, although based on maps of the sorts mentioned, must attempt to set forth economic conditions. Certainly the aim of such a map would be to represent the ways in which the people of the area make their living and the character of this living, insofar as these things can be placed within the inelastic frame of a map.

The problem may be attacked, in the mapping of a small area on a large scale. In this way simplicity of material is secured and the amount of generalization is much reduced. Of such a map it may be expected that it shall succeed in building up a panorama of its area, and that this representation will place in full and true light the area both as home and place of business of a group of people. The analysis, thus undertaken, may be expected to bring out the distribution of the significant activities of the area, to suggest their interrelations, and to indicate the local economic opportunities and disabilities. This means a census taking in map form with two principal problems, a major one in the selection of the economic conditions to be represented, and a secondary one in securing proper graphic expression. The present paper is concerned primarily with the former problem.

Since utilization is the key-note, the map must distinguish first of all between productive and non-productive areas, or else, between what the Census designates as improved and unimproved land. In the former classification the critical element is yield, in the latter, labor. In this way a grouping of land utilization of the following sort may be arrived at: Barrens, woodlands, permanent pastures and meadows, cultivated lands.

ZOOLOGY.

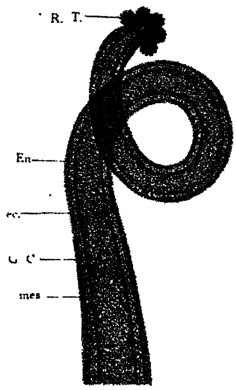


Fig 1

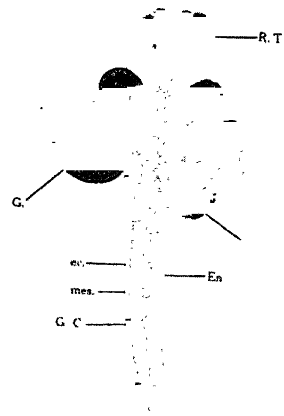


Fig 2

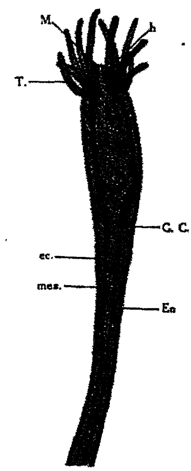


Fig. 3

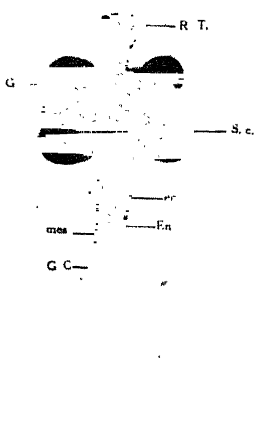


Fig. 4

Fig. 5

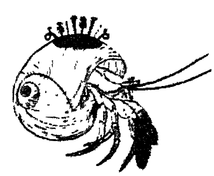


Fig. 6

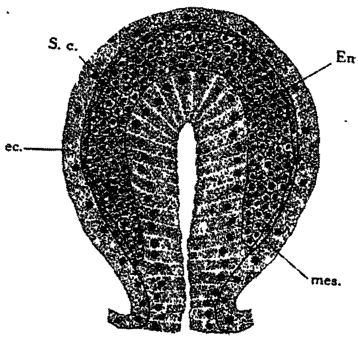


Fig. 1

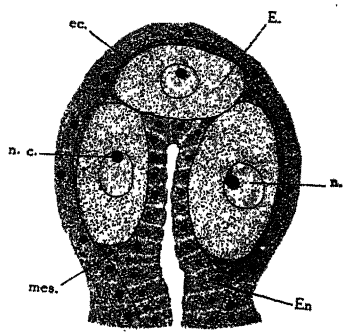


Fig. 2

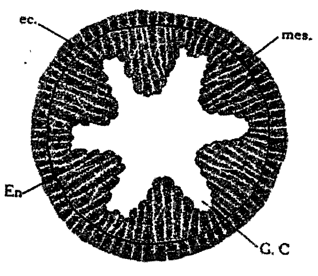


Fig. 3

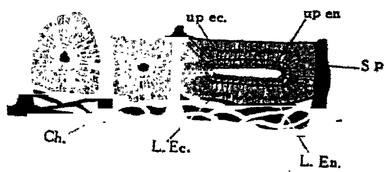


Fig. 4

THE MORPHOLOGY, STRUCTURE AND DEVELOPMENT OF HYDRACTINIA POLYCLINA.

J. A. PLACE.

With drawings by J. T. Pickering.

INTRODUCTION.

During the summer of 1914, the Invertebrate Zoology class at the Marine Biological Laboratory, Woods Hole, while working on *Hydractinia polyclina*, experienced some difficulty in finding, and identifying Tentacular polyps. The question arose as to their constancy in the colony, and it was suggested by the instructors as a good subject for special work. The purpose of this paper is to offer a brief account of the morphology, structure, and development of the various kinds of polyps that exist in a colony of *Hydractinia polyclina*.

HABITAT.

Hydractinia polyclina lives in a state of symbiosis with the Hermit-crab, forming over the shell of the latter a soft, pinkish covering. It appears that both are benefited by this community life, for while the Hydractinia colony is furnished with transportation it, in turn, affords protection to the Hermit-crab, not only by obscuring its shell from view, but also by its possession of stinging cells by means of which it forms a defense against the enemies of the Hermit-crab.

The constant association of these forms together led to the belief that the life of the Hermit-crab was necessary to the existence of Hydractinia. That Louis Agassiz found them growing in abundance, attached to rocks in tide pools; that Samuel F. Clarke later found them growing on a wharf at Fort Wool, Chesapeake Bay; that two students of Woods Hole Laboratory found them growing on Mytilus edulis and Limulus; that during the summer of 1891 Dr. Conklin found them growing on the Fish Commission Wharf, Woods Hole; that they are frequently found growing on sponges about Woods Hole region: have proved their existence independently of the Hermit-crab. Besides having removed the occupants from shells bearing Hydractinia colonies, we placed the shells in wire baskets and suspended them below low tide from a wharf. There we left them three weeks, during which time the colonies became very luxuriant on the empty shells.

An additional advantage received by the Hydractinia colonies is that of food supply furnished by the young paguri. Miss Bunting reports that many of these are devoured by the polyps as they swim out from the maternal shell.

21st Mich. Acad. Sci. Rept., 1919.

MATERIAL AND METHODS.

The material for this work was obtained while studying at the Marine Biological Laboratory, Woods Hole, during the summer of 1914. The shells possessing Hydractinia colonies were found at low tide in Eel Pond. In order to prevent the polyps from contracting into abnormal shapes they were narcotized by adding, drop by drop, a solution of ten per cent chloreton in absolute alcohol till all power of contraction was lost. They were preserved in a four per cent formalin solution. For histological structure the best results were obtained with iron-hematoxylin stain. Sections were made from seven to twelve micra in thickness. Camera lucida drawings were made of various magnifications.

THE POLYPS.

The gasterozooids, as a rule, are the most numerous representatives of the colony; but sometimes during the summer months reproduction is so active that the blastostyles occasionally are equally as numerous. These are the longest of the polyps, often exceeding one-fourth inch in length. They possess a conical hypostome, terminating in a large mouth. Around the base of the hypostome are two circles of tentacles which increase in number with age from ten to thirty. The longest tentacles that occur on members of the colony are found here; they are crowded with nematocysts. The external surface is covered with a layer of ectoderm, which is continuous with the upper ectoderm of the coenosarc.

Since it is the function of this polyp to collect food for the entire commonwealth, it possesses the largest gastral cavity (Pl. 1, Fig. 3). It is lined with a single layer of endoderm, continuous with that of the endodermal canals of the coenosarc.

The ectoderm and endoderm are separated by a thin structureless layer of mesogloea, which will not be referred to in description of the other polyps, as it is common to all.

The blastostyles are either male or female, though both sexes are never found in the same colony. The mouth, and gastral cavity are both small. A short distance below the mouth are two circles of tentacles varying in number from ten to thirty, but, unlike those of the gasterozooids, are very rudimentary, consisting of knob-like structures crowded with nematocysts. Immediately below the head the walls constrict into a narrow neck and then enlarge into a globular dilatation from which arise the sporosacs. In both sexes the reproductive cells arise in the body and migrate to the sporosacs. In female colonies the sporosacs are filled with eggs that can be seen through the thin ectodermal walls in the unstained, as well as stained, condition (Pl. 1, Fig. 2). In the male colonies the reproductive elements are small, very numerous, and stain more deeply than the body cells (Pl. 1, Fig. 4). Below the sporosacs the body again narrows often into a slender thread.

The difference in appearance between the male and female colonies—the male sporosacs being often much elongated and of a yellowish tint, while the female are rounded and rose-colored—caused Van Beneden to regard them as two distinct species, which he described in a paper published in 1844 as Hydractinia lactea and Hydractinia rosea.

The dactylozooids are about the same size throughout their length. Their distal extremity is surrounded by a circle of rudimentary tentacles from ten to sixteen in number. There is a very small mouth in the center. These have strong, muscular walls and are capable of coiling and uncoiling themselves. As their function is chiefly to protect the other members of the colony, they possess an abundance of nematocysts (Pl. 1, Fig. 1).

The tentaculozooids are extremely slender, though often exceeding the dactylozooids in length (Pl. 1, Fig. 5). They are capable of great extension, and are characterized by Mr. Hincks as floating like long fishing lines through the water. In preserved material, on the other hand, they are contracted to such an extent as to render them extremely difficult to find. They are situated near the outskirts of the colony, and are usually few in number as compared with other members. The tip only is covered with nematocysts. No mouth is present, and the gastral cavity is very small.

These were regarded by Allman as abnormal dactylozooids on account of their paucity. Colcutt, however, found them present in every colony of *Hydractinia echinata*, and considered them as normally present. Mr. Hincks reports them as constantly occurring. He also states that he distinguishes no difference between his *Hydractinia echinata*, and *Hydractinia polyclina* of Agassiz. I have found the *Hydractinia polyclina* of Woods Hole region to correspond in every particular with Colcutt's *Hydractinia echinata*, but the skeleton differs in minor details from that of *Hydractinia echinata* as described by Mr. Hincks, to which reference is made under the discussion of the skeleton.

THE SKELETON.

The skeleton is a chitinous structure which forms an irregular crust on univalve shells, or other objects on which the colony is growing. The skeletal structures penetrate the shell by dissolving the calcareous substances with an acid, or erosive agent which the animal secretes. The chitin is then secreted by the lower ectoderm of the coenosarc in thin layers (Pl. 2, Fig. 4). These are so closely attached to the shell that the latter must be dissolved away with dilute hydrochloric acid in order to obtain good specimens of skeleton. Pieces of skelton can then be cut from the shell and thin sections made.

The skeleton is overlaid by coenosarc, consisting of two layers of ectoderm, enclosing between them a number of endodermal tubes which branch and anastomose promiscuously. These are connected at intervals with the canals of the polyps, whose ectoderm and endoderm are continuous respectively with

the upper ectoderm of the coenosarc, and the endoderm of the tubes. In this way the gastral cavities of all members of the colony are placed in direct communication with each other.

At intervals the skeleton projects above the coenosarc, forming conical, smooth spines and spinules. These sometimes form bridges of chitin over an intercommunicating tube, which led Mr. Hincks to conclude that the chitinous covering existed above, as well as below the coenosarc (Pl. 2, Fig. 4).

Carter (1873) tells of a specimen in the British Museum in which the whole of the shell has become transformed into the horn-like skeleton of Hydractinia. From the smooth internal appearance, he infers that the shell had been tenanted by an Eupagurus, which left after the entire shell had been transformed.

HISTOLOGY.

The lower ectoderm of the coenosarc is composed of long, slender cells, quite irregular in shape. They are more or less vacuolated, and contain a single nucleus situated near the center of the cell. The nucleus is oval in shape, and contains several nucleoli. It is the function of this layer to secret, extend and renew the chitinous skeleton.

The upper ectoderm of the coenosarc is formed of a single layer of cells more regular in size, and more cubical in shape. Nematocysts are occasionally present in this layer (Pl. 2, Fig. 4).

This layer is continuous with that of the polyps, the main difference in the latter being a greater variation in shape of their cells.

The endoderm of the coenosarc is made up of a single layer of cubical cells containing a single, oval nucleus in their center.

In the gasterozooids the endoderm contains long, narrow cells, which vary in length so that the free ends are not at the same level. In this way longitudinal ridges are formed in the lumen, which in cross section present a very irregular appearance (Pl. 2, Fig. 3). As this is especially characteristic of the nutritive polyps, it is evident that even in this low form of life the rudimentary alimentary canal is thrown into elevations for the increase of surface.

These cells are wider at their free ends, and are vacuolated. Their nuclei are oval, are situated near the middle region of the cell, and possess one or more nucleoli.

The endoderm of the blastostyles is composed of long, narrow ciliated cells. In the head region these often contain several nuclei, but in the body they possess a single, large nucleus.

The endodermal cells of the dactylozooids are approximately equal in size. They usually contain many vacuoles, and a single nucleus, which is situated in the middle of the cell.

The tentaculozooids possess long, narrow cells, which are more regular in size and shape than those of the other polyps.

EMBRYOLOGY.

The ova have their origin in any part of the endoderm below the gonophores and migrate upward between the ectoderm and endoderm, until they reach the gonophores. Here they remain till they ripen and are laid (Pl. 1, Fig. 2).

The origin of the sperm cells is a little more complicated. At the outset the ectoderm of the gonophore begins to divide into two layers, the inner one of which stains deeply and is destined to form the sexual cells. This layer, in turn, divides into two, an outer thin layer, consisting of a single row of cells, and an inner one, which rapidly separates into several rows of cells. These stain deeply and are known as spermatoblasts. They become specialized to form the mature spermatozoa.

The ova are fertilized at the moment of ejection. The polar bodies are rapidly given off, cleavage takes place and a ciliated planula is formed. This becomes attached at one end, elongates, and tentacles are formed at the other. At the basal end prolongations are given off to form the beginnings of the tubular network. These subdivide promiscuously, the intervening spaces being gradually filled in by the extension of the coenosarc, and the secretion of spines and spinules.

CONCLUSIONS.

1. Hydactinia polyclina, though almost invariably associated with the Hermit-crab, is capable of an independent existence.

2. In every Hydractinia colony there are normally present four kinds of polyps:

   Gasterozooids.
   Blastostyles.
   Dactylozooids.
   Tentaculozooids.

3. The function of the gasterozooids is to collect, digest and absorb food for the entire colony; that of the blastostyles is reproduction. The function of both the dactylozooids and tentaculozooids is to defend the colony against enemies, the latter being especially adapted to this service by reason of its great length.

4. Judging from the accounts of the many investigations made upon *Hydractinia echinata*, we have concluded that it is identical with *Hydractinia polyclina.*

BIBLIOGRAPHY.

Colcutt, M. C. On the structure of *Hydractinia echinata.* Journal Mic. Soc., vol. 40, p. 77-99, Pl. 1.

Brooks, W. K. The life history of the Hydromedusae. Mem. Boston Soc. Nat. Hist. 3.

Agassiz, L. Contr. Nat. Hist. U. S. 4, p. 227.

Beckwith, Cora J. The genesis of the plasma structure in the egg of *Hydractinia echinata.* Journal of Morphology, June, 1914, p. 189-252.

Bunting, M. The origin of sex cells in Hydractinia and Podocoryne, and the development of Hydractinia. Journal of Morphology, vol. 9, p. 203-231.

Carter, H. J. Transformation of an entire shell into chitinous structure by the polype Hydractinia, with short descriptions of the polypidoms of five other species. Ann. Mag. Nat. Hist., 4th Ser., vol. 11, p. 1-15.

Carter, H. J. On new species of Hydractinidae, recent and fossil, and on the identity in structure of *Millepora alcicornis* with Stromatopora. Ann Mag. Nat. Hist., 5th Ser., vol. 1, p. 298-311.

Hincks, Thomas. A history of the British hydroid zoophytes, vol. 1, Pl. 4, vol. 2.

Goto, Seitaro. On two species of Hydractinia living in symbiosis with a Hermit-crab. Journal Exp. Zoo., vol. 9.

Smallwood, W. M. A re-examination of the Cytology of Hydractinia and Pennaria. Biol. Bull. 17, No. 3, p. 209-233.

EXPLANATION OF FIGURES.

PLATE 1.	Fig. 1.	Dactylozooid	x 90
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REFERENCES ON PLATES.

Ch.......Chitinous skeleton.
E.......Egg.
ec......Ectoderm.
En......Endoderm.
G.......Gonophore.
G.C......Gastral cavity.
h.......Hypostome.
L. Ec....Lower Ectoderm.
L. En....Lower endoderm.
M.......Mouth.
mes.....Mesogloea.
n.......Nucleus.
n.c......Nucleolus.
R.T.....Rudimentary tentacles.
S.c......Sperm cells.
Sp......Spine.
T.......Tentacle.
up. ec...Upper ectoderm.
up. en...Upper endoderm.

THE INDIVIDUALITY OF THE GERM-NUCLEI DURING THE CLEAVAGE OF THE EGG OF CRYPTOBRANCHUS ALLEGHENIENSIS.

*A Preliminary Report.**

BERTRAM G. SMITH.

Early observers of the process of fertilization described the meeting of the sperm-nucleus and the egg-nucleus and their complete fusion to form a single zygotic nucleus. Later it was found that in many cases, though apparently not in all, the two germ-nuclei merely become opposed without actual fusion. In tracing their further history, attention early became focused upon the chromosomes, and it was shown, in certain cases, that the germ-nuclei give rise to two independent groups of chromosomes which separately enter the equatorial plate, and whose descendants pass separately into the daughter cells. "Later observations have given the strongest reasons for believing that, as far as the chromosomes are concerned, a true fusion of the nuclei never takes place during fertilization, and that the paternal and maternal chromatin *may* remain separate and distinct in the later stages of development—possibly throughout life." (Wilson, 1900). At the present time we may state with some confidence that a fusion of maternal and paternal chromatin never takes place in the somatic cells,. and that in the lineage of germ cells it does not occur until a pairing of maternal and paternal chromosomes, called synapsis, takes place in preparation for the maturation divisions. In a sense, the process of fertilization is not complete until synapsis, when for the first time maternal and paternal chromosomes are brought together in intimate and orderly union, in some cases amounting to actual fusion.

This conclusion, which is of the most fundamental importance since it vitally concerns the mechanism of inheritance, is in part based upon indirect evidence. In the attempt to establish the principle by direct demonstration, the chief difficulty has been encountered in tracing the maternal and paternal chromosome-complexes through the resting stage of the nucleus. In only a very few cases has this been done with even partial success; the observations of Haecker (1892 and 1895), Ruckert (1895) and Conklin (1901) are of most importance in this connection.

In the developing egg of the amphibian *Cryptobranchus alleghenienis* I have found material very favorable for the study of this problem; for the early cleavage nuclei are almost without exception distinctly double throughout the entire resting stage, each consisting of two separate nuclear vesicles, and the origin of these two components from the maternal and paternal germ-nuclei respectively has been traced through several of the early nuclear divi-

*Illustrated by lantern slides and microscopical demonstrations.

sions. In the later cleavage stages the nuclei are typically, and perhaps always, likewise double, but irregularities occur in these stages and the double nature of the nucleus is not always demonstrable.

In the fertilization of the egg of *Cryptobranchus allegheniensis* the egg-nucleus and the sperm-nucleus do not fuse, but come to lie side by side with nuclear membranes intact. During the long resting stage that precedes the formation of the first cleavage spindle, each germ-nucleus maintains strict individuality; there is close association, but no actual union, and certainly no mingling of structural contents. The two asters take up positions on opposite sides of the resting germ-nuclei, in the same horizontal plane, and close to the region of contact of the germ-nuclei. The rupture of the nuclear membranes and the formation of distinct chomosomes does not take place in the two germ-nuclei simultaneously, but one of the germ-nuclei becomes active somewhat in advance of the other.

In the fully-formed mitotic figure the two groups of chromosomes, of maternal and paternal origin, respectively, remain visibly distinct. Further, in the anaphase these two chromosome groups of diverse origin may be traced, in a series of preparations, step by step into the daughter-nuclei, where each group becomes enclosed in a separate nuclear vesicle. Each daughter-nucleus thus comes to consist of two distinct nuclear systems, derived from the egg-nucleus and the sperm-nucleus, respectively. Except for a diminution in size, the appearance of each daughter-nucleus closely simulates that of the original fertilization-nucleus with its two resting germ-nuclei.

The orientation of the two nuclear vesicles of the newly-formed daughter-nucleus is somewhat variable, but the final position assumed in preparation for the second mitosis is established with great regularity. The two asters take up a position on opposite sides of the daughter-nucleus, such that a line connecting them lies parallel to the newly-formed first cleavage furrow; if the two nuclear vesicles are not already ranged midway between the two asters, they rotate to this position. This arrangement ensures a segregation of maternal and paternal chromatin in the ensuing division, and the second cleavage mitosis is in all essential respects a repetition of the first.

This same type of cell division persists through the early cleavage stages at least, though there is increasing difficulty in distinguishing the maternal and paternal chromosome groups through the most active stages of mitosis. In the resting stages of the nuclei of the late blastula, the structure is still typically double, but it is often quadruple, with four distinct nuclear vesicles of equal size. In still other cases there are three nuclear vesicles, one of them equal in bulk to the other two combined. It is comparatively rare to find nuclei divided in any other ways than those mentioned, but deeply-lobed nuclei are quite common in these later stages.

These observations give strong support to the principle that maternal

and paternal chromosomes are equally represented in the daughter cells, but it should not be inferred that strict segregation of the germ-nuclei is necessary to bring about this result. It is not claimed that the individuality of the germ-nuclei during embryonic development is a universal phenomenon; there are too many observations that give positive evidence to the contrary. Where it exists, the separation of maternal and paternal chromatin-complexes into distinct groups within a single nucleus affords a striking exemplification of the deeper and more universal truth that each germ-nucleus is represented in its entirety in every cell, somatic as well as germinal, of a developing organism; but the mingling of these two complexes probably makes no essential difference in the distribution of the chormosomes following mitosis. The chief importance of the observations here recorded on the behavior of the nuclei in the developing eggs of *Cryptobranchus* lies in the fact that we have here the material for an ocular demonstration of a principle long ago foreseen by Huxley (1878) when he said: "The entire organism may be compared to a web of which the warp is derived from the female and the woof from the male."

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REFERENCES.

Conklin, E. G. 1901. The individuality of the germ-nuclei during the cleavage of Crepidula. Biological Bulletin, Vol. II.

Haecker, V. 1892. Die Eibildung bei Cyclops und Canthocamotus. Zool. Jahrb., Bd. V.

Haecker, V. 1895. Ueber die Selbstandigkeit der vaterlichen und mutterlichen Kernbestandtheile wahrend der Embryonal-entwicklung von Cyclops. Archiv f. Mikr. Anat., Bd. 46.

Huxley, T. H. 1878. Article "Evolution," Encyclopaedia Brittanica, Vol. VIII, pp. 744-751.

Moenckhaus, W. J. 1894. The development of the hybrids between *Fundulus heteroclitus* and *Menidia notatus*, with especial reference to the behavior of maternal and paternal chromosomes. Journal of Anatomy, Vol. III.

Ruckert, J. 1895. Ueber das Selbstandigbleiben der vaterlichen und Mutterlichen Kernsubstanz wahrend der ersten Entwicklung des befruchteten Cyclops-Eies. Archiv f. mikr. Anat, Bd. 45.

Wilson, E. B. 1900. The cell in development and inheritance. The Macmillan Co.

Wilson, E. B. 1913. Heredity and microscopical research. Science, May 30.

MASTODON REMAINS FOUND IN GRATIOT COUNTY, MICHIGAN.

H. M. MACCURDY.

The relation of the remains of Mastodon to the glacial and post-glacial deposits has always been of interest, and information concerning this relation is of value in the study of the distribution of these animals both geographically and chronologically.

Parts of three skeletons of Mastodon have been found in the vicinity of Alma. The parts as they were found are now in the Hood Museum of Natural History at Alma College.

The Alma Area,[1] which includes the north half of Gratiot County, presents three distinct physiographic types of surface: old lake deposits, low morainal hills, with intermorainal deposits, and fossil beaches. The fossil beaches divide the area roughly into two nearly equal parts; passing in the main in a north and south direction across the area somewhat east of Ithaca, which is in the geographic center of the county, and St. Louis, lying near Alma on the north-east. To the east of this line are found the old lake deposits, now fertile farm lands; to the west are found low morainal hills with inter-morainal depressions, with occasional outwash plains. The morainal hills increase in elevation toward the west, but they are very well suited to and are occupied in farming. The old lake beaches are obliterated in many places, but are rather clearly marked in others. This beach is the highest in the series of beaches surrounding the present Saginaw valley and bay, and would thus be the beach of the old Lake Saginaw.

The fragments of the first skeleton in the collection were found on the farm of the late Mr. William Pitt on the south half of the northwest quarter of Section 22, Township 12, Range 4, west. They were lying in the surface layers of the gravelly out wash and were not in contact with muck. The fragments were scattered and were apparently disturbed by water. They show considerable mineralization and are well preserved, though much broken. From this specimen there were several teeth, the atlas, a portion of a humerus, one-half of the lower jaw, a few vertebrae and ribs, and pieces of other bones. The degree of mineralization and the position in the deposits indicate a period considerably earlier than in the cases of the other two specimens to be mentioned.

The parts of the second specimen to be found were found in what is now the southern part of the City of Alma, near the Alma plant of the Michigan Sugar Company. They were imbedded in muck, which had caused considerable

[1]Soil Survey of the Alma Area, Michigan. Hearn, W. Edward, and Griffin, A. M.; U. S. Dept. of Agri., Bureau of Soils, Advanced sheets, Field Operations, 19 104.

softening of the bones and teeth. The parts found in this case include a full set of molars, one tusk so softened that only about two feet of the tip of the tusk remains unbroken, the atlas, several ribs and vertebrae, a number of toe bones and some pieces of bones. What is of considerable interest in this find is the finding of a number of seed cones of the common black Spruce, Picea mariana, and a portion of a horn of the elk or Wapiti. The native habitat of the black Spruce at the present time is well known. It seems that this specimen must have lived much later in time than the one mentioned before.

The third specimen to be found within the area was uncovered in 1909, on the farm of Mr. Albert Smith, six miles southeast of Alma, on the southwest quarter of the northeast quarter of Section 17, Township 11 north, Range 2 west. This specimen was found in an inlet from the old beach described above. The bones were lying on a gravelly bed, and were covered over by marl, which was in turn covered by about two feet of vegetable deposits, now largely turned to muck. The bones were scattered about and some of them show some signs of wear from the action of water. The skull was unintentionally broken open by the workmen who found it. In this condition it shows well the relatively small brain cavity and the remarkable alveolar structure of the walls of the cranium. No teeth nor tusks were discovered, but a fragment of the root of a molar was still imbedded in the maxillary, and served to identify the specimen without any question. A number of vertebrae, several ribs, with some fragments of ribs, the head of a femur, a hip bone, one scapula and a number of pieces of bones were found. The parts are all in a fair state of preservation and show some mineralization. The presence of the marl served to protect the bones from the disintegrating action which might otherwise have been caused by the overlying vegetable decay.

The relation of the remains of the specimen to the fossil beach is significant, and serves to give it a place both chronologically and geographically.

Hay[2] advances good reasons for thinking that Mastodon lived possibly from the pleiocene to the end of the pleistocene. The last of specimens described above most probably lived during the Algonquin-Iroquois stage; the one just previous to the Champlain substage, in which as yet no Mastodon remains have been found. The second specimen may have lived at a later date. In fact, it might possibly have been in the Champlain substage, so far as might be judged from the conditions. At any rate, it is reasonable to suppose that the last two specimens represented in the collection are among the last representatives of "a mighty race" which, according to Hay, "had weathered the vicissitudes of four or five glacial periods."

[2]Hay. O. P. On Some Proboscidians of the state of New York. Science N. S. Vol. XLIX, pp. 377-379.

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DIVISION, NUCLEAR REORGANIZATION AND CONJUGATION IN ARCELLA VULGARIS.

H. M. MACCURDY.

(Abstract.)

The number of times a given individual, as recognized by shell characters, divides in pedigreed cultures was studied. A given individual produces a limited number of daughter cells, and was not found to continue to divide indefinitely, as has been maintained. The number of times a given individual was found to divide varies from none up to twenty-seven, the highest number found in a single case.

The daughter cells, and in turn their offspring, behave in a similar way, with the exceptions indicated.

After a period of vegetative divisions in a line derived from one individual, a period of "depression" occurs. This "depression" does not necessarily occur in all of the offspring nor at the same time, but it usually does occur in most of the offspring during a given period of time. Some of the features marking this period are: Reduced activity, such as division, locomotion, feeding; "punctate" shells, "empty" shells and uninucleate individuals. *Arcella vulgaris* typically has two vegetative nuclei. These features are not necessarily accompaniments of "depression," and may sometimes be found in unfavorable culture; but they do occur in the best of cultural conditions at the times of "depression." This is significant.

Individuals may pass successfully through this period and enter upon a new period of vegtative divisions or they may not do so.

While some members of a line are "depressed," others were found to undergo conjugation.

After conjugation, the individuals after separation may differ markedly in size from the parent line. It is believed these are "mutants." "Mutants" may arise without an evident "depression" period. Jennings, 1917, found what he regarded as mutations in *Difflugia corona*.

After conjugation, the individuals after separation usually proceed to divide within one or two days. The exconjugants tend to produce the same numbers of daughter cells at about the same rate. Ex-conjugants of Paramoecia have been shown by Jennings to tend to have similar fission rates.

In lines derived from a single individual, "depression" periods and conjugation have been found to occur at intervals of from four to six weeks in most cases. This is for pedigreed cultures extending from the first of January, 1918, to the twenty-third of June, 1918, including many thousands of individuals.

Preparations of cells made during the time of depression show the vegetative nuclei inactive or breaking up, and "secondary" nuclei forming from part of the chromidial net. These secondary nuclei have been observed to enter daughter cells, while the old vegetative nuclei remain in the old shell, in many cases. Preparations of conjugating individuals show remarkably similar conditions.

These so-called "depression" periods are not a necessary event in the life of the organism, since the reconstruction of nuclei can take place without any very noticeable "depression" period.

A "Uninucleated" race, that is, a line derived from a uninucleate individual, was maintained through periods corresponding to the periods referred to above. Some individuals with two nuclei occurred as offspring in this line also. Thus the so-called vegetative nuclei are not necessarily organically connected, but are merely in association.

A three nucleated race was also maintained from May 13th to August 19th, 1918. The individuals of this "line" have a larger average size than those of the "uninucleated" line, but the number of nuclei in an individual does not necessarily determine its size, since many three nucleated individuals we found smaller in size than many of the larger nucleated individuals. Individuals with two and with even one nucleus occurred as offspring in the three nucleated line. These occurred in perfectly healthy cultures, and are not to be assigned to cultural conditions.

If the nuclei constitute the germplasm, its continuity is interrupted at the time the old vegetative nuclei cease to divide and begin to disintegrate, and the secondary nuclei are organized from the chromidial net and pass into the new daughter cells. If chromidiogamy occurs at the time of conjugation, as is maintained, nuclear continuity is still interrupted, and is only secured in the process of the construction of new nuclei out of the chromidial net. There is thus a discontinuity of nuclei with a nuclear cycle of development. If the nuclei are successively similar at corresponding stages, the lines run true; if not, variations due to their dissimilarities are produced.

Arcella vulgaris is sensitive to environmental conditions, and all possible care was taken to eliminate such influences. While it may not be possible to entirely eliminate these, the data upon which these conclusions are based are derived only from normal, clean, healthy cultures. Cultures showing unfavorable conditions were discarded. The cultures were started in the latter part of September, 1917, with specimens taken from a small pond on the campus of Johns Hopkins University, and the experiments were carried forward in the Zoölogical Laboratories of the University until the 28th of June, 1918, when they were transferred to the laboratories of the Brooklyn Institute of Arts and Sciences, Cold Spring Harbor, Long Island, New York. There they were continued until August 19th, 1918. I am especially indebted to Professor

H. S. Jennings of the Johns Hopkins University for the privileges extended to me while there, and to Dr. C. B. Davenport, Director of the Station for Experimental Evolution, Cold Spring Harbor, Carnegie institution of Washington, for the opportunity to continue the work into the summer months. A full account is to be published.

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SEX DETERMINATION IN THE WHITE-FLY ALEURODES.

NORMAN R. STOLL.

In 1917 Williams, in the Journal of Genetics, suggested that *Aleurodes vaporariorum*, the common "white-fly" of the green-house, is a form in which males are produced (in the American members of the species) from both unfertilized and fertilized eggs, while females come from fertilized eggs only. Experiments to test this conclusion by breeding flies from Ann Arbor greenhouses showed that

(1) the progeny of virgin females are exclusively males, and

(2) females were found in large majority in some cultures of mated mothers.

On the basis of the law of chance it can be shown that the probability of the high female ratios referred to in No. 2 is so exceedingly small as to be regarded as impossible, if selected from a population in which males and females were produced in equal numbers. The conclusion is drawn that females come only from fertilized eggs, males only from unfertilized eggs; but that mated females may lay unfertilized eggs, as well as fertilized, as in the honey-bee.

(Complete paper to be published in Genetics.)

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THE DISTRIBUTION OF THE UNIONIDAE IN ALASKA AND BRITISH AMERICA.

BY BRYANT WALKER.

(Abstract.)

This is a preliminary and partial report on a study of the Unionidae of Alaska and British America undertaken at the request of the Canadian Biological Survey, and the final report will be published by that Survey.

As only a portion of the material submitted for examination by the Survey has been determined, the exact number of species represented in the area and the range of the several species has not yet been definitely ascertained, and therefore will not be discussed at the present time.

But enough is now known of the general character of the fauna and its distribution to determine its salient features and the sources from which it was in all probability derived. This is the ground covered by the present paper.

North America, north of the Ohio River and west of the Mississippi River, is divided, so far as its Unione fauna is concerned, into three great faunal areas, known as the Atlantic, Mississippi and Pacific areas. All three are represented in the area studied.

The Atlantic fauna occupies New Brunswick, Nova Scotia and the lower portion of the St. Lawrence valley, extending west as far as Lake Ontario and thence northwesterly through Georgian Bay into Lake Superior. The region lying north of the St. Lawrence valley and between Labrador and Hudson's Bay is entirely unexplored, and its Unione affinities are wholly unknown. This fauna, except as remnants may have survived in favorable localities along the coast during the glacial period, is wholly post-glacial, and was derived from immigration from the southeast.

The Pacific fauna is found only west of the great range of mountains extending from Alaska to Mexico. Its relations are wholly with the northern Eurasian fauna, and it was undoubtedly derived from some of the earlier migrations over the land bridges between Asia and Alaska.

The entire country lying between these compartively restricted areas is occupied by the Mississippi fauna. Just how far north this fauna extends is a most interesting question, and one that yet remains to be determined. In British America the Mississippi fauna occupies two distinct areas, separated by the northwestern extension of the Atlantic fauna.

Between Lake Superior and the lower St. Lawrence the fauna of the St. Lawrence valley is Mississippian, and was derived by post-glacial migration from the Ohio valley. This has been discussed by Walker (Nautilus, XXVII, 1913).

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The entire basin of Hudson's Bay and its tributary streams, so far as known, is also occupied by the Mississippi fauna. This area was peopled by an early post-glacial migration from the Mississippi valley at the time when glacial Lake Agassiz emptied south through that river.

Detroit, Michigan.

NOTES OF THE PRESENCE OF LARVAL TREMATODES IN THE EYES OF CERTAIN FISHES OF DOUGLAS LAKE, MICHIGAN.

BY E. PRISCILLA BUTLER.

(Abstract.)

In the summer of 1917, young Herring Gulls which were fed upon dead fish picked up on the beach of Douglas Lake became very highly infested with trematode parasites. Among these were certain Holostomidae, belonging to the genus Strigea and to an undetermined genus. In the following summer search was made for the larval forms of these trematodes in the fishes of the lake. Larval Holostomidae of the generic groups Diplostomulum and Tetracotyle were found in large numbers in the eyes of certain of the fishes.

Seventy-nine specimens, belonging to seven species, of fish were examined for parasites. Fifty per cent of the Trout Perch, sixty per cent of the Rock Bass, and seventy-two per cent of the Yellow Perch examined were found to be so infested. The data secured from the other species, namely the Common Bullhead, the Common Sucker, the Common Shiner, and the Pumpkinseed, are not sufficient to warrant any conclusion as to the degree of infestation of these species, because of the small number of specimens examined.

All the parasites found in the eyes were in the free living state. They occurred within the pupil, in the anterior and posterior chambers, on the iris, in the pigmented tissue of the choroid lining, and, most commonly, in the vitretous humor. Their presence in such large numbers indicates that the eyes of these fish form a natural habitat for Diplostomulum and Tetracotyle.

European species of Diplostomulum and Tetracotyle which infest fish are known to develop into adult forms, Hemistomum and Strigea respectively, which are parasitic on water-birds. The relation of the larval trematodes found at Douglas Lake in 1918 to the adult forms taken from the Herring Gulls the previous summer is not definitely proved, but is strongly suspected.

The early development of Diplostomulum and Tetracotyle, before the stages found in the fish, is not known.

Further investigation of this problem is planned.

University of Michigan.

THE CESTODE PARASITES OF THE PERCH.

GEORGE R. LA RUE.

(Abstract.)

The cestodes found in a considerable number of perch have been studied and found to belong to three species. Of these, two infest the intestine of the perch in relatively small numbers while the remaining species occurs in the plerocercoid stage encysted in the viscera. These species and their occurrence may be summarized thus:

Proteocephalus pearsei mihi. This species in both the juvenile and adult form occurs in the intestine of perch in certain Wisconsin lakes, Douglas Lake, and Hubbard Lake, Alcona County, Michigan. Adults were found in 11 perch out of 525 perch examined by the writer and others. This is 2.095 per cent. The juvenile form has been found in a larger number of hosts, in the neighborhood of 11 per cent.

Proteocephalus ambloplitis (Leidy). The plerocercoids of this species occur encysted in the viscera of perch taken in lakes of Wisconsin, Michigan, and Lake Erie. About 52 per cent of the perch are infested with this worm.

Bothriocephalus cuspidatus (Cooper). This species has been found but rarely in examinations of perch made by the writer and apparently not at all by certain other investigators whose records have been available to the writer. It has been recorded by Pearse in unpublished researches. In the writer's examinations of perch this species was found but twice in 181 perch or a little more than 1 per cent.

From a study of the records the conclusion is drawn that the perch is rarely parasitised by adult Proteocephalids.

An explanation of this infrequent infestation is perhaps to be sought in the varied diet of the perch. Since *P. ambloplitis* is found as plerocercoids encysted in the viscera of the perch and since the perch is cannibalistic in its habits one would be justified in looking for the adult of this worm in the intestine of the perch. Thus far there are no records of its occurrence there. The only explanation that can be offered for the present to account for the non-occurrence of the adult in the perch is that the intestine of the perch does not offer a proper habitat. As to the elements of that habitat which are incompatible no explanation can be offered.

University of Michigan, April 3, 1919.

THE AQUATIC ADAPTATIONS OF PYRAUSTA PENITALIS GRT. (LEPIDOPTERA.)

PAUL S. WELCH.

(Abstract.)

Aquatic Lepidoptera have developed ingenious methods, both morphological and physiological, of solving their problems of maintenance. *Pyrausta penitalis* Grt. is successfully adapted to aquatic surroundings although devoid of special structural features peculiar to such an adjustment. It likewise retains the ability to exist under terrestrial conditions, at least to a limited extent. The major adaptations appear in connection with food getting, locomotion, and respiration. Feeding on the exposed surfaces of *Nelumbo* leaves it is safeguarded from wave-action by the construction of silk surface webs; of marginal, rolled-up tunnels; and of short, vertical, petiole burrows. An efficient form of surface swimming constitutes the principal method of locomotion. Direct access to the atmosphere, demanded by the method of respiration, is insured by feeding on a waterproof leaf-surface, and by tunnel construction in the slightly elevated petiole junction. Pupation in petiole burrows is accompanied by cocoon formation and the construction of a special closing device at the top of the tunnel. This closing device is not developed when pupation occurs either in the peripheral tunnels or in terrestrial plants.

THE OCCURRENCE OF A SPECIES OF ECHINOSTOMIDAE IN LARUS ARGENTATUS.

WM. KORDES BOWEN.

(Abstract.)

Certain Echinostomidae were collected by Dr. G. R. La Rue from the intestine of young herring gulls *(Larus argentatus)*. The gulls were obtained from Goose Island, near Douglas Lake, Michigan, during the summer of 1917. They were three or four weeks old, and were fed for some time on a diet consisting chiefly of raw fish.

It has as yet not been possible definitely to place the parasite under consideration in any present genus. According to the classification proposed by Dietz, and adopted by Luehe in his manual on Trematodes, which is the seventeenth volume of the "Suesswasserfauna Deutschlands," the trematode in question appears to be very closely related to the genera Mesorchis and Monilifer, but does not fit with certainty into either.

Dept. of Zool., University of Michigan.

THE ENCHYTRAEIDAE (OLIGOCHAETA) COLLECTED BY THE CANADIAN ARCTIC EXPEDITION OF 1913-1916.

PAUL S. WELCH.

(Abstract.)

The collections of Enchytraeidae made by the Canadian Arctic Expedition (Southern Division) of 1913-1916 constitute the first records of these annelids in the vast territory lying between Greenland and Bering Strait. They were sent to the writer for identification and found to contain seven species representing four genera, together with four groups of sexually immature specimens representing two genera. With the exception of two new species, all have been recorded from arctic Eurasia. An interesting similarity of the arctic enchytraeid fauna of North America and Eurasia is thereby indicated.

SOME OBSERVATIONS ON THE LONGITUDINAL FISSION OF THE TENTACLES OF HYDRA FUSCA.

A. M. CHICKERING.

(Abstract.)

The observations recorded in this paper show that longitudinal fission as well as budding may increase the number of tentacles in Hydra fusca; that longitudinal fission of a tentacle may result in producing two new tentacles equal in size and otherwise normal or it may produce two of unequal size and abnormal position; that longitudinal fission usually occurs from the distal toward the proximal end but may proceed in the opposite direction; that along with the process of longitudinal fission there occurs a rapid degeneration process resulting in the elimination of some of the tentacles; and that the processes described seem to be associated in some manner with a diseased condition of the animals.

NOTES ON A SPECIMEN OF *STYLEMEYS NEBRACENSIS.*

E. C. CASE.

(Abstract.)

A specimen of this turtle discovered by the University of Michigan expedition in the Big Bad Lands of South Dakota is in such a singularly good state of preservation that it permitted the shell being removed from the matrix and mounted as a recent specimen would be. This has resulted in

recognizing that the turtle, Stylemeys, has a much higher carapace than has been supposed and that it strongly resembles the shell of the Galapagos turtle. The form was evidently much more terrestrial in habit than has been supposed.

The same specimen included within the shell the remains of the pelvis and pectoral girdle and seven of the cervical vertebrae. The pelvis is peculiar in the extremely heavy ischial region resembling in this regard the land turtle Cinoxys.

SANITARY AND MEDICAL SCIENCE.

A MICROSCOPIC METHOD OF EXAMINING BUTTER FOR MICROORGANISMS.

G. L. A. RUEHLE.

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In examining a substance for the presence of microorganisms, it is always desirable to be able to analyze the material microscopically as well as culturally. Without this microscopic check, one is apt to get not only an entirely erroneous view of the number of microorganisms present and of their condition in the material, but one may also miss a whole group of organisms entirely, due to the fact that they do not grow on the medium presented to them.

With these facts in view, some work has been started with the purpose of devising and perfecting a technique which will enable us to examine butter microscopically. Since starting the work three other microscopic methods for the examination of butter have been found, described in the literature. They are (1) Roth's method[1] for the examination of butter for the Tubercle organism (2) Löhnis' method[2] for demonstrating bacteria in butter and (3) Schneider's microscopic method.[3] All of these methods are merely for the demonstration of bacteria in butter and all of them depend on the use of the centrifuge and the microscopic examination of the stained sediment. None of them, it seems, will be useful in determining even the approximate numbers of microorganisms in the butter. For microscopically demonstrating the presence of organisms in butter it is unnecessary to centrifuge the butter. This has been shown in the present work, incomplete as it is. All that is necessary is to dissolve some of the butter in a fat solvent in a separatory funnel. After this stands for a short time some of the microorganisms and particles of casein and some of the moisture of the butter will settle out in the lower part of the funnel and then may be spread on a slide; stained and examined under the microscope. When so examined, it was found that a large proportion of the bacteria were imbedded in the particles of casein. This would indicate that any cultural method of counting the microorganisms in butter would give counts of bacteria much below the actual number present in the butter. Therefore, it was deemed advisable to attempt to develop a direct microscopic technique for counting the microorganisms in butter similar to the Breed method for counting bacteria and leucocytes in milk. This seemed to be simple enough but as will be shown later, unexpected difficulties were encountered.

After some experimentation the following technique was adopted and is still being studied:

One gram of butter was weighed out and transferred to a clean separatory funnel. One cubic centimeter of hot water was added to the butter and the whole mass agitated until the butter was melted and thoroughly mixed with the water. Then 50 c.c. to 100 c.c. of ether, gasoline or other fat solvent was added to dissolve the fat, when it was allowed to stand until the two liquids had separated. The aqueous portion was drawn off into a graduated cylinder and an equal amount of sterile skim milk which had been allowed to sediment for a week or more after sterilization was added to the aqueous extract of the butter. After mixing 1/50 of a cubic centimeter of the mixture was spread out with a needle on a glass slide so that it covered an area of 1 square centimeter. Sometimes a larger amount of butter was used but in those cases a larger amount of warm water was used so that in every case 1/50 c.c. of the final mixture represented approximately 1/100 gram of the butter. The smears were then treated in the same manner as the milk smears are treated in the Breed method of counting bacteria in milk; namely, the smears were dried quickly on a warm plate, immersed in xylol for a minute to dissolve any trace of fat, fixed for one minute in alcohol, stained with a one per cent aqueous methylene blue solution, destained in alcohol and dried. Two duplicate smears were always made for each sample. The counting was done under a compound microscope in the same manner as in the Breed method. In this work an E. Leitz 1/12 oil immersion objective was used with a No. 1 ocular and the draw tube adjusted to 152 mm. There was also used a special ocular micrometer marked into quadrants with cross-hairs and a circle 8 mm. in diameter. This combination give a factor of 650,000 for every bacterium seen in one field. From 10 to 40 fields were counted and averaged per sample. The following results were secured (see table):

Butter Sample No.	Kind of Cream.	Plate Counts.	Microscopic Count. Groups.	Microscopic Count. Individuals.
1.	Pasteurized, ripened by starter	620,000	5,035,000	7,962,500
2.	Pasteurized, ripened naturally	168,000	9,250,000	14,925,000
3.	Pasteurized, ripened naturally	101,000	666,250	980,000
4.	Pasteurized, ripened by starter	5,000,000	9,600,000	14,880,000
5.	Pasteurized, ripened by starter	1,240,000	25,350,000	40,950,000
6.	Raw, ripened naturally	15,100,000	6,435,000	11,115,000
7.	Raw, ripened naturally	16,600,000	10,010,000	17,680,000
8.	Unknown	3,165,000	3,022,750	5,590,000
9.	Raw, ripened naturally	9,100,000	5,622,500	8,582,500
10.	Unknown, dairy butter	3,597,000	2,762,500	4,290,000
			325,000 torulae	325,000 torulae

In every case when the cream was first pasteurized the results by the microscopic group count were higher than by the plating method, which is not surprising since the dead cells would stain as well as the living ones. But where raw cream was used the results by the plating method are higher than the microscopic group count. This is opposed to all experience with the microscopic technique when applied to milk, where one usually gets results

from 2 to 5 times as large with the microscope as with the petri plate. The reason for this is not clear, though our experience with sample No. 10 suggests a partial explanation. Representative colonies on the plates were fished grown in milk, and stained. It was found that the bacteria took the stain very poorly. Various stains were tried, but with little better success except with Giemsa's stain, which differentiated the bacteria, and the casein of the milk very well, when the culture was grown in milk. But when this stain was applied to the butter smears it did not stain the bacteria more successfully than other stains. Another possible cause for overlooking bacteria in counting the smears is the small size of the usual flora of butter, which consists principally of Bacterium lactis acidi. Neither of these explanations seems to fully explain the discrepant results and further search is being made for the reason. In two of the experiments the non-aqueous portion was examined for bacteria, but none were found. It is realized that the foregoing discussion is based on very limited data. The main reason for presenting it at the present time is in the hope that some suggestion may be received here that will help to solve the difficulties encountered.

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REFERENCES.

[1]Tanner, F. W. Bacteriology and Mycology of Foods. John Wiley and Sons, 1st ed., page 428.
[2]Löhnis, F. Laboratory Methods in Agricultural Bacteriology. Chas. Griffin & Co., Ltd., page 81.
[3]Bowhill, Thos. Manual of Bacteriological Technique and Special Bacteriology. Wm. Wood & Co., 2nd ed., page 26.

THE RELATION OF *BACILLUS BOTULINUS* TO CERTAIN PHASES OF HOME ECONOMICS AND AGRICULTURE.

ZAE NORTHRUP.

(Preliminary Report.)

In speaking of *B. botulinus* in its relation to certain phases of home economics and agriculture, I am regarding it, from personal experience, as the representative of a group of Gram positive, spore-forming, gas and toxin-producing anaerobes. In the report of the Bureau of Chemistry, Washington, D. C., for the fiscal year ending June 30, 1918, this same idea is expressed regarding *B. botulinus* after a comparative study was made of all known strains.

The toxin produced by this interesting group of anaerobes; rather than poisonous ptomaines, is now thought by certain investigators to be the chief source of the type of food poisoning caused by toxic products resulting from bacterial growth in certain types of food, i. e., toxemia, fatal or otherwise, following the ingestion of *B. botulinus* toxin is of more common occurrence than actual ptomain poisoning, although neither are of very common occurrence.

B. botulinus received its name from the fact that it was originally isolated (by van Ermengem, 1896,) from sausage which had caused fatal poisoning; since then, however, it has been found in other forms of raw and cooked meat prepared for human consumption, in canned meats, vegetables and even fruits, and in silage and certain kinds of hay, while in nature it has been found to occur in pig and chicken feces. Thus it is seen that this group of organisms most probably has a fairly wide distribution, and because of its habitat, oxygen and reaction requirements, and resistance to high temperatures, it lends itself readily to creating disturbances under certain circumstances because of its power to produce toxin.

Little is known about the conditions under which this group of toxicogenic bacteria finds its way into human and animal foodstuffs, yet as our knowledge is added to bit by bit by new work from different sources, some of these hitherto deep mysteries become cleared up. An instance illustrating this point occurred in this state; corn silage from which anaerobes resembling *B. botulinus* were isolated, was cut in the fall, but not shocked. The stalks lay on the ground for more than a week before being ensiled, during which time a light rain fell. Theoretically this gave ideal conditions for *B. botulinus* to contaminate the cornstalks through contact with the well-manured soil, and to begin growth, since it is now known that this anaerobe can grow well

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aerobically in the presence of certain molds, e. g., *Fusarium* sp. (Graham and Brueckner, Jour. Bact. IV, 1919, p. 8), and of certain aerobic bacteria.

Thus it is being assumed that manure may be one carrier of this organism, and I believe that such an assumption may be justified, as Graham, Brueckner and Pontius found that the feces from chickens liberally fed with *B. botulinus* cultures, when mixed with a wholesome feed and fed to a horse proved fatal, showing that either the toxin passed through their alimentary tract unharmed or that the organisms survived and multiplied in the feces after they were voided, producing toxin characteristically. (Ky. Sta. Bul, 207, 1917, p. 523).

Again, in my own experiences, spore-forming anaerobes closely resembling the ones fed were recovered from the feces of guinea pigs fed both on pure cultures of *B. botulinus* and of organisms of this type isolated from spoiled peas and chicken soup. If the assumption is correct, that the feces of susceptible or non-susceptible animals, used experimentally or otherwise, may be considered as an important factor in the distribution of this group of toxin-producing organisms, then this may explain why certain foodstuffs, both animal and human, perhaps more especially the former, do become contaminated with *B. botulinus*, and in their conditions of storage, foster its development.

The statement is made in various texts that *B. botulinus* requires a decidedly alkaline medium for its development and toxin production; that it will not even grow in an acid medium. These assertions are now known to be incorrect. The experiences of different investigators have proved that under certain commonly occurring instances, this group of anaerobes can and does develop readily and produces an exceedingly potent toxin sometimes in the presence of acid. In the case of poisonous silage, responsible for the death of horses and cattle, these bacteria are found in the surface layer, where enough acid is usually formed to inhibit the growth and consequent toxin production of *B. botulinus*, if we are to believe the assertions made by various authors. The explanation may be offered that this organism lives in the surface silage in association with certain molds which have the power of destroying acid. Graham and Brueckner cite an instance of this (Jour. Bact. IV 1, p. 8). To quote: "In media of an acid reaction (+2.5) in association with *Fusarium* sp., favorable growth took place aerobically. * * * It is probable that the soluble toxin is generated even under aerobic conditions in media of an acid reaction in association with *Fusarium* sp., and other saprophytic bacteria, since mixed cultures of this character proved fatal to guinea pigs per os."

A statement made by Dickson shows, moreover, that an acid reaction is not inimical to *B. botulinus*. He says, "An acid reaction of as much as 3.2 per cent to phenolphthalein does not prevent the formation of the toxin" (Jour. Amer. Med. Assn, LXV, 1915, pp. 492-496). This amount of acid was formed in a can of string beans inoculated with a pure culture of a strain of

B. botulinus of low virulence. The majority of the cans of string beans in this same series varied from 2 to 2.5 per cent normal acid. Dickson cites another case where death followed the eating of canned pears and of canned apricots, the latter being a decidedly acid fruit. (Ibid. LXIX, 1917, p. 966-968).

In my own experience, February 9, 1918, a series of cans of common vegetables and acid fruits was inoculated with a pure culture of a strain of low virulence for exhibit purposes. The can of cherries (a pint Mason jar) a month later showed a bulged top, and over a year later, March 17, 1919, the can was open aseptically, giving every evidence of a swell. Microscopic examination of the juice showed no yeasts, only occasional bacteria with spores nearly terminal, and many free spores. This juice contained 17 per cent normal acid. Cultures were made at the same time to see if *B. botulinus* had survived this excessively long sojourn in a highly acid medium. Also some of this juice (0.25 c. c.) was fed to a guinea pig. No growth, and no ill effects resulted.

These results of different investigators, even though few in number, seem to suggest strongly that anaerobes of this group can and do grow in highly acid media and produce toxin under certain circumstances. In agriculture, this phase of their life history will bear extensive investigation in connection with the silage obtained from the strictly anaerobic portions of the silo; in home economics, in connection with temperatures employed in cooking and canning operations.

This brings us to the consideration of the resistance of *B. botulinus* and its spores to various degrees of temperature. Here again text books are at fault in copying from one another the statement that *B. botulinus* spores are relatively non-resistant to heat. They make the statement that heating one hour at 80 degrees C., or 15 minutes at 85 degrees C., destroys them. In a recent number of the Journal of the American Medical Association (Vol. 72, No. 2, January 11, 1919), work done at Leland Stanford University under the Botulism Research of the California State Council of Defense, shows quite conclusively that the spores of certain strains of *B. botulinus* will survive the processing temperatures of the cold pack canning method when subjected to these temperatures for the period of time prescribed for the various food products; that blanching in boiling water for five minutes does not materially injure spores of resistant strains of *B. botulinus;* and what is more pertinent, that a steam pressure of 5, 10 or 15 pounds for 10 minutes will not kill the more resistant spores of this species.

A noteworthy instance developed under my personal observation. During the fall of 1917 I assisted in canning eight chickens. Pint "seal-fast" jars and new rubbers were used. The chickens were cooked in an open kettle till the meat fell from the bones; they were then boned and canned. Several cans were filled with almost solid meat, while a number of cans were used for the soup alone. Cooked barley and vermicelli were added to several cans of the

soup; those remaining were left clear. All these cans were heated in a pressure cooker for 1.5 hours at 27 pounds pressure, the pressure at which the safety valve was regulated. The gas was shut off at the end of this time and the pressure was allowed to go down gradually without opening the pet cock. As soon as the cover was removed, the cans were taken out, the covers clamped down immediately, tested for leakage and then stored in a cool place. One or two cans were opened and used during the winter and the contents were excellent. Later in the season, about the middle of April, 1918, one of the cans of chicken soup (without cereal) was taken from storage for immediate use and upon examination. it appeared to be leaking. There was no question of spoilage, as the odor around the rubber was extremely vile. Although the appearance of the can was not noticeably different from normal, no one possessing even a poorly developed sense of smell would ever think of tasting the contents of this can.

Bacteriological analysis of the liquid from this can resulted in the isolation of an anaerobe resembling *B. botulinus* morphologically. One-tenth of a cubic centimeter of the soup was fed to a guinea pig (weight 692 gms.) and the same amount heated to 80 degrees to destroy any toxin present was fed to a second guinea pig (weight 497 gms.) April 20. During a period of 15 days the guinea pig which received the heated soup gradually became more and more emaciated, and finally was found dead the morning of May 4th. Cultures were made from various parts of the body and organs, but anaerobic growth was present only in those taken from the stomach and intestinal contents. The work with these cultures had to stop at this time and has not been resumed since.

A point worthy of note in connection with the experiment just cited is the fact that the guinea pig was killed by eating the heated soup, which would not be expected if an ordinary toxin was present. This particular feeding experiment was not repeated, but similar results were obtained in guinea pig feeding experiments, using heated and unheated pea juice obtained from cans of spoiled peas which had produced serious illness on tasting. The guinea pigs fed the heated pea juice died first in every case. This experiment is being repeated with filtered pea juice and chicken soup. The pigs now showing symptoms are those fed with filtered heated juice. These peas had been canned by the cold pack method and heated three hours in a water bath. My personal experiences in feeding experimental animals with heated pea juice (heated to 80 degrees only) make me hesitate to advise the safety of eating of suspicious canned vegetables, even after boiling them for five minutes. (Burke; p. 92, Jour. Amer. Med. Assn. 72, Jan. 11, 1919).

Another example of an anaerobic organism resembling *B. botulinus* morphologically, Miss Ruth Normington isolated from canned peas, whose complete history is known. The pint Mason jar containing the peas, was autoclaved for one hour at 15 pounds pressure; all other directions for the cold

pack method were followed. Miss Normington attempted to determine the thermal death point of this organism, and found in one trial that it survived a temperature of 120 degrees C. (15 lbs. pressure) in the autoclav for 10 minutes, but was evidently destroyed at the same temperature and pressure when heated 20 minutes. These results check with those of Burke of California using known strains.

These few recently worked out examples make one regard with suspicion the verity of the previously printed statements concerning the thermal death point of the spores of the *B. botulinus group.* Thus the conclusion must be drawn that the only method of processing for certain types of canned foods which are not easily penetrated by heat and which are liable to contain resistant spores, is by steam under pressure, and that a comparatively long processing period must be used. These suggestions are at present in opposition to government teachings. This phase of the subject has no direct bearing on the problem as it is related to the care and use of silage, except that one young farmer suggested that certain kinds of silage may be treated with boiling water previous to filling the silo. His idea was to moisten the silage and make conditions more anaerobic. This practice might have other desirable results.

One very important point brought out by Burke is that in determining the thermal death point, a definite time limit cannot be set for the development of the organism owing to the fact that they have a period of lag depending directly upon the time and temperature of heating. The longest period of incubation before growth appeared in culture was 53 days. This strain of *B. botulinus* (X) had been heated for 10 minutes at 15 pounds pressure. I have found this same thing true in determining thermal death points of organisms of this type. This point is very important in canning, as the organisms may not develop immediately, but may show up several months to a year or more after canned.

The next phase of the subject I wish to discuss has to do with the influence of certain chemicals, namely, salt and acids, on the growth and toxin production of *B. botulinus.* A 10 per cent salt solution is said to destroy the spores of this organism within a week (Kendall: General Pathological and Intestinal Bacteriology), while 5 to 6 per cent salt will prevent multiplication (Herzog: "Disease-Producing Microorganisms). Miss Normington carried out salt concentration experiments under my direction with 19 strains of *B. botulinus* from different sources, using a dextrose broth having a reaction of –0.5 per cent normal, and employing additions of salt ranging from 1 to 10 per cent inclusive. Growth was noted in all concentrations with all strains in practically every case in periods from 27 to 49 days after inoculation. Toxin production was not determined. It seems to be a fact that this organism can multiply readily in a slightly alkaline solution in the presence of salt concentrations varying from 1 to 10 per cent. We know nothing, however, about the effect of a combination of salt and acids such as would occur naturally in

fermenting vegetables (sauerkraut, string beans, etc.), nor do we know what the effect other combinations, e. g., heat and chemicals (such as salt, organic acids) would have on *B. botulinus* and its spores. In fact, innumerable problems present themselves as the study of this organism broadens.

Experiment Station.

Michigan Agri. College.

STUDIES IN THE BACTERIOLOGY OF THE COLD PACK CANNING METHOD.

RUTH NORMINGTON.

In making determinations of the bacteriology of cold packed canned goods, I restricted my work to canned peas, all of which had been heated in the autoclav at 15 pounds pressure for the time given by the latest government bulletins.

The peas were canned in two lots, the first consisting of thirteen quarts, which were picked one day, partly shelled, put in the refrigerator, the shelling completed the second day and canned in quart Mason jars. These were heated one hour at 15 pounds pressure. The second lot, consisting of seven one-pint jars, was prepared similarly, except that the peas were not refrigerated over night. Both lots were picked during the hot, dusty weather last summer (1918).

These cans when examined a month later all showed spoilage by presence of gas and more or less sediment at the bottom of the can. Five cans from each lot were examined. The five from the first lot examined showed leakage, but my findings indicate that these were, in part at least, probably due to the pressure of gas in the cans. Two organisms were found in the first can and three in each of the other four. In the second lot, gas was present but no leakage. Two organisms were isolated from the first can, four from the second, three from the third and fourth, and two from the fifth. Two of the cans had an odor of spoilage; the odor of the others was practically normal.

The cans before opening were wiped off with a 1-1000 mercuric chloride solution, then alcohol was poured over the top and burned off. The lid was loosened and lifted, but not removed. Three sets of gelatin agar tubes were inoculated from the can contents, using the loop dilution method, one set being used as shakes, while the other two sets were poured for aerobic and anaerobic plates. The anaerobic plates were placed in a Novy jar filled with hydrogen. All were kept at room temperature since spoilage occurred at that temperature. Titrations were made of the juice from each can, using phenolphthalein as indicator. The acidity varied as follows:

SET I.		SET II.	
Can 1	.076/N	Can 1	.028/N
Can 2	.086/N	Can 2	.038/N
Can 3	.082/N	Can 3	.033/N
Can 4	.102/N	Can 4	.025/N
Can 5	.073/N	Can 5	.046/N

Unspoiled peas have an acidity of about .02/N.

21st Mich. Acad. Sci. Rept., 1919.

Bacterial counts were made by the quantitative plating method and by the direct miscroscopic method. The results per cubic centimeter were as follows:

	Plate Method.	Direct Microscopic Method.
SET I.		
Can 1	361,883	3,033,856,000
Can 2	700	568,848,000
Can 3	300,000	568,585,000
Can 4	776,400	209,612,000
Can 5	1,386,000	2,439,772,800
SET II.		
Can 1	1,500	14,221,200
Can 2	2,000	569,084,000
Can 3	3,435,333	43,923,000
Can 4	6,224,000	1,611,736
Can 5	295,666	474,040

This variation between the miscroscopic and plate count from the same can may be explained by the fact that bacterial action had not developed far enough to make up for those killed in processing, or organisms may have grown and succumbed later to the byproducts produced, or the media used may not have been favorable for the organisms present. However, a special effort was made to see if the organisms found were microscopically the same as those on the original stain from which counts were made.

Gelatin agar shakes of pure cultures from colonies on the plates were made. Duplicates were found of organisms on the aerobic and anaerobic plates, all but one organism, which was a strict anaerobe, being facultative anaerobes.

Besides running cultures through ordinary media aerobic and anaerobic cultures were made in test tubes of sterile peas in distilled water. The anaerobic culture was covered with about one inch of paraffin oil. Starch agar plate streaks and starch broth cultures were also made and the thermal death points determined.

The strict anaerobe found had the cultural and morphological characteristics of *B. botulinus;* this organism lived after heating in test tubes of neutral broth for 10 minutes at 15 pounds pressure in the autoclave. It was killed when heated 20 minutes. This grew symbiotically with a resistant spreading facultative anaerobe, but was separated by means of dilution shakes in gelatin agar made in glass tubes with a rubber stopper in the bottom. As the anaerobic colonies developed first, transfers made from the bottom were finally successful in obtaining a pure culture.

Of the other organism found, one appeared in five different cans, in three cans from the first set and in two cans from the second set. After making these cultural tests, some strikingly similar characteristics were found:

All were spore forming rods.

All gave the indol test.

All caused peptonization in litmus milk, which became alkaline.

All liquefied gelatin.

None produced gas in any of the three sugar fermentation tubes or in protein free asparagin solution, but most of them produced gas in peas.

Most of them digested starch, many with the production of sugar, although complete starch reduction was observed where no sugar test with Fehling's solution was found.

A number of these bacteria would not produce spores in broth, although spores were produced both in peas and in gelatin agar.

Nearly all organisms survived heating in the autoclave at 10 pounds pressure for 20 minutes, but were killed when autoclaved at this pressure for 30 minutes. Again they withstood autoclaving at 15 pounds pressure for ten, but not for twenty minutes. These tests were made with test tubes of neutral or slightly alkaline broth, inoculated with the spores.

I have not worked out as yet how long it would take to kill these organisms when in a can of peas. Work has been done with tin cans along that line, however, by A. W. Bitting and K. G. Bitting, who state in their bulletin, "Bacteriological Examination of Canned Foods," that it takes over 20 minutes for the center of a can of peas to reach 248° F., which is the temperature at 15 pounds pressure. With a glass jar there would be a variation, as there would be also with different cans of peas depending upon the proportion of solid and liquid matter present.

From these data and the results which I obtained. it is perfectly logical to conclude that the time given in government bulletins for the processing of cold pack canned vegetables is *not* sufficient in many cases. It is known that in a large number of cases these directions have worked satisfactorily, but many instances are also known where housewives have attempted to conserve food by this method and had dozens of cans spoil when these directions had been followed absolutely. I personally know of an instance where an organism resembling *B. botulinus* survived the three-hour hot water bath heating prescribed. Food poisoning was caused in this case. How long a period of processing necessary for absolute safety, is still a problem to be solved.

Michigan Agr. College.

AGRICULTURE.

ORIGIN AND DEVELOPMENT OF PEDIGREED VARIETIES OF GRAIN.

BY H. S. OSLER.

The development of improved varieties of grain has attracted the attention of scientists and the practical farmer since the early part of the nineteenth century. Every one familiar with plant breeding associates with its development the names of such men as Vilmorin, Le Couteur, Shirreff, Hallet, Nilsson-Ehle and a number of others who were the pioneers in improving crops. Since that time the names of scores of workers have been associated with problems of investigation relating directly to crop improvement. Practically every State Agricultural Experiment Station maintains a special department, devoting most of its time to a study of the laws of inheritance and their application to the improvement of animals and crops.

A study of the history of the present important varieties of grain show that they came to use largely in three ways: By Introduction, Selection and Hybridization.

Considering the comparative newness of our country and realizing that all cereals, with the exception of maize, are indigenous to the eastern hemisphere, it is natural that already existing varieties afford a large field for investigation. No doubt thousands of introductions never developed superior quality and were discarded; but out of the large number introduced we have retained and developed a few grains that are now recognized as important economic varieties. This is especially true of our wheat and oats.

The now existing Mediterranean variety of wheat introduced into Delaware in 1819 is still a prominent variety in many districts. This variety is a hardy, red-chaffed, awned, prolific winter wheat, producing a large red kernel of good milling quality. Other important introductions of wheat are the Fife and Turkey Red varieties. The former of these is one of the popular spring wheats of Canada and the Northwest, and was introduced by David Fife into Canada from Glasgow, Scotland. Its origin has been traced from here to Dantzic, Russia. The Kubanka, a variety of spring wheat, is another important recent introduction.

Turkey Red, the second variety mentioned, also known as Crimean wheat, is the most important variety in the hard winter wheat district. This variety came from the southern Russian province of Taurida, and was introduced into Kansas by the Mennonites in 1873, but did not come into prominence until 1890. Kharkov is a recent introduction of hard winter wheat, and this variety has made it possible to greatly extend the hard winter wheat area.

Among the prominent varieties of oats introduced, mostly from different provinces in Russia, are the Swedish Select, Kherson, Sixty-Day and Clydesdale.

The barley group has one important variety known as Manchuria. This was introduced into Wisconsin from Germany in 1861. It was brought into Germany in 1859 from the mountains of Manchuria.

During recent years the Michigan Agricultural Experiment Station has been fortunate in securing an introduction that has added greatly to the food production of the state during the past few years. In 1909 there was introduced into Michigan a Russian rye. This crop was introduced by a Russian by the name of Rosen, who at that time was a student in the Michigan Agricultural College. The crop produced from the sample proved to be much superior to the common rye grown at the station. The Rosen rye compared with common rye has a much shorter and stiffer straw and much larger and more symmetrical heads. The heads of common rye vary considerably in size, and the rows contain only scattering kernels. At the present time fields of Rosen rye produced from certified seed may be inspected, and if the crop meets the standard, it is classed as pedigreed seed and sold under guarantee through the Michigan Crop Improvement Association. The pure seed of this variety was first distributed in 1912; and in 1916 there were 15,000 acres grown in the state. In the fall, 1918, there were about 6,000 acres of pedigree and 426,000 acres of mixed Rosen rye seeded. The total acreage of the state, seeded last fall, is about 483,000 acres. The fact that rye is an open fertile plant, makes it difficult to maintain purity, especially when common rye is grown nearby. Ten to fifteen bushels is an average yield for common rye, while forty to forty-five bushels per acre is not uncommon for pedigreed Rosen rye.

Although we have many important varieties of grain that have come to use through introduction, there are others of importance that were secured through careful and painstaking selection. It is largely in the field of selection and hybridizing (crossing) that the plant breeder and the scientist have been interested, and it is to this group of men that the farmer is greatly indebted for the present understanding of the fundamentals of crop improvement.

It is not the purpose of this paper to discuss the theory and effects of mass selection and pure lines, except as they relate to the laws of crop improvement. We cannot, in passing, help but recognize the facts established by the work of Galton, Mendel, DeVries, Johannsen, Nilsson-Ehle and other noted scientists.

To Mendel, DeVries and Johannsen is given the credit of explaining the principles upon which the occurrence of hereditary variation depends. These men worked upon the principle that plants and animals are composed of a group of distinct and independent unit characters, and that nature, oftentimes

assisted by man, produces a re-combination of characters, asserting itself in a new individual, which in the case of crops may become a new variety. The classical researches of Johannsen, in establishing his theory of pure lines, did much toward pointing out a constructive plan in plant breeding, and the fact that prominent varieties of self fertilized crops have originated from the selection of a single individual, proves the workableness of Johannsen's theory of pure lines.

At the present time the stability of a pure line in grain has been fully demonstrated, and considerable data are available to prove its immutability. A pedigreed variety of a pure line is the progency of a single self fertilizing individual. A number of our prominent varieties of pedigreed grain have been developed from the selection of pure lines.

Fultz wheat is a prominent variety, which was produced by selection. It originated from a selection made by Abraham Fultz in Mifflin County, Pennsylvania, from a field of Lancaster, and is an awnless variety, selected from a field of awned wheat. Its general distribution is evidence of its excellent quality.

White Clawson is another variety that came into prominence about 1871. This selection was made by Garrett Clawson from a field of Fultz, a semi-hard red wheat, at that time quite generally grown in New York state.

Gold Coin is another variety that came into prominence in New York state. This selection was made by Ira W. Green at Avon, New York, and was an awnless variety, with white kernels and selected from an awned red kernel variety.

Our present Fife and Bluestem varieties have been the source of a number of selected varieties. No doubt most of these new varieties were nothing more than the segregation of a pure line.

One of the more recent selections of wheat that has come into local prominenec and which is now quite widely grown, is the variety, Red Rock. This variety was originated at the Michigan Agricultural Experiment Station from an individual kernel picked out of a white wheat (Plymouth Rock). It was first planted in the fall of 1908, and is a hardy, stiff strawed, red chaffed, awned red winter wheat. Its exceptional winter hardiness, good yielding ability and high quality makes it a very desirable variety. Considerable credit is due Professor Spragg of the Michigan Agricultural Experiment Station, in giving to the farmers of the state a variety of wheat of such high quality. Comparative tests conducted at the Michigan Station, where a large number of different varieties were grown under the same conditions, showed that the winter resistance, yield and quality of Red Rock was equal to the best varieties and superior to many. The fact that it is quite hard makes it excellent wheat for the production of bread flour.

The distribution of this wheat in Michigan began in 1913. Peck samples were sent out to a number of county agents. The tests under field conditions

proved the variety to be well adapted to localities where wheat can be profitably produced.

In 1913 a peck sample was sent to Allegan county and in 1917, 300 acres were produced which would pass inspection and could be sold as pedigreed seed. tI is estimated that 4,000 acres were grown in the state in 1917, and in the fall of 1918, 17,000 acres of pedigreed seed were planted. In addition to this acreage seeded with pedigreed seed, there was a considerable acreage seeded with Red Rock, which was slightly mixed with other varieties. This would probably aggregate 107,000 acres. The total wheat acreage of the state is approximately 860,000 acres.

The conservatism of the average farmer has been a great hindrance to the development of a community interest in crop improvement. In many sections every farmer grows a different variety. Where such a community condition exists it is almost impossible to keep a variety pure. The threshing outfit, going from one farm to another, is a common cause of the mixtures. It will appear, therefore, that eternal vigilance is necessary in order to maintain pure varieties of grain.

Community coöperation in standardizing varieties is very essential. Considerable progress has been along this line in the state of Michigan by local communities coöperating, through their farm bureau, with the Michigan Crop Improvement Association.

In crop improvement the field of greatest interest to the scientist is the study and development of new varieties by hybridization. Compared with the results of introductions and selections, very little improvement of cereals has been accomplished by this method, both in Canada and the United States. No doubt the students of the present and the future will give considerable attention to this line of research. The possibilities of improvement in this way, accompanied by discriminating selection in the hands of the skillful breeder, seems to be practically unlimited.

One of the most prominent varieties of cereals produced by crossing or hybridization is Marquis wheat. This variety was produced by crossing Calcutta Hard Red, an early ripening Indian wheat, and Fife. The cross was made by Dr. A. P. Saunders at the Agassiz Experiment Farm in 1892. Following that time, selections were made from the progeny of the cross resulting in our present Marquis variety of spring wheat. This is the most important variety grown today in the spring wheat district.

Winter Fife, early Red Clawson and Preston are among other important varieties developed by hybridization. A few varieties of other grains produced by hybridization and selection appear to have considerable merit.

The problem of the improvement of farm crops, carrying with it the work of the scientist and the practical farmer, can be summed up in the statement, "Growing Better Crops." The "Growing of Better Crops" will avail us little unless with it we "Grow Crops Better." Crops with the inherited ability for

increased production must have the proper environment in which to develop. Well-bred and selected seed must also have the advantage of good cultural methods, better preparation of seed bed and more intelligent use of plant foods. "To Grow Better Crops" and "To Grow Crops Better" should be the motto of the scientific agriculturist of the future.

Ann Arbor, Mich.

ELEMENTS OF HIGHER FECUNDITY.

M. E. DICKSON.

The number of eggs the hen lays is taken as the measure of her producing power. At birth a miscroscopic examination of the ovary reveals innumerab'e ovules and at death, from old age, autopsy shows apparently like numbers of undeveloped yolks. The number produced is insignificant. Phenomenal individuals make today the maximum production at 314 eggs in twelve months. while not infrequently do we find hens that have never laid, although externally and internally identical. Influences, however, within the physical efforts of the caretaker in his feed and management of the flock bear directly upon the results obtained. From our observations, breeding for egg yield has not approved itself. It is not possible for poultry breeders to sell males for fabulous prices, based upon a parentage of high production. Continuous work with trap-nests on inheritance of high production and dominant aspects of fecundity has proved disappointing. Close breeding for egg yield apparently is invariably coupled with an intolerant tax on vitality—until in a course of four or five generations the germs lack sufficient strength to develop properly and fail to perpetuate the high laying factor. An out cross of blood lines at this point restores the vitality and the egg production is improved. More strength is bred into the fowls and evidence of more producing power is manifested in the egg yield.

To withstand the tax of higher production there must be a corresponding understanding of higher vitality as a basis for selection, independent of and unbiased by egg yield. Such selection methods having among others the following: The most important factors are, namely, the size of the fowl, coupled with distinctly early maturing characteristics, as would be evidenced in rapidity of growth of the secondary sexual organs, such as the comb of the pullet or male, the age of the cockerel at first crowing and age of pullet at time of her first egg; the rapidity of feathering in feather tracts and quick moulting as chicks, all of which are correlated with fecundity. The variety of fowl to be disregarded, excepting, however, those breeds having marked tendencies toward meat production and the extreme of this type, bantams, etc., including the Asiatic, Oriental and Ornamental classes, and possibly a few minor classes.

The relationship of the producing powers in the common varieties is surprisingly close, particularly will this be noticed in taking the average egg yield of a large number of individuals for comparison. The following figures illustrate this. The figures were taken from five egg-laying contests held at

New Jersey, Vancouver, Connecticut and two in Missouri, 1915. The different locations being arranged to cover a variety of environment. The data are compilations of the different varieties gathered from each of the five contests, and represent a fair average of the producing power of each.

In all there were 2,375 birds contesting. The average production per individual was 151 eggs. The Leghorn average was 163; the Rhode Island Red, 158 eggs; the White Wyandotte, 156 eggs, and the Barred Plymouth Rock, 152 eggs. Where there are too few hens contesting there is liable to be an average production considerably over 151 eggs, but in a large number of cases it appears that this is about the producing power of the average variety. Why this average should be so close in so many varieties is altogether more likely to be accredited to the influences of environment and general management. In this case all varieties were given an equal chance and all produced approximately the same results. These conditions were not ideal, but represent the best efforts, however, on the part of the management of the contests, in so far as the knowledge of proper ways of today is understood. Under better conditions it is likely that better results could have been attained. Should the influence of breeding for higher fecundity be present, it seems the reputed egg varieties would be more outstanding when compared with the various varieties of dual purpose type, as below mentioned:

	No. Hens.	Average.
Barred Rocks	161	152
White Rocks	110	148
Buff Rocks	35	134
Buff Wyandottes	26	175
Silver Campine	46	110
White Orpington	80	114
Buff Orpington	82	124
Rhode Island Red	378	158
White Wyandotte	205	156
White Leghorn	891	163
Anconas	56	147
All sitting birds		144
All non-sitting birds		151
Total	2,375	151

Poultry Department.

Michigan Agr. College.

THE MICHIGAN CROP IMPROVEMENT ASSOCIATION.

J. W. NICOLSON.

Pedigreed grains were first distributed from the breeding plats of the Michigan Agricultural College in 1909. The first few released were varieties of wheat, such as Plymouth Rock, American Banner, Shepherd's Perfection, etc. These were sent out in small quantities during the years 1909 to 1911 to a few interested farmers, who tried them out and report the results obtained to the Experiment Station.

These varieties proved satisfactory in many sections of the state, and the demand increased for further work along this line.

It was early realized that some systematic method of distribution would be necessary to give every one interested an equal chance to participate in the benefits to be derived from the use of improved seed. Furthermore, the value of plant breeding work and the returns on the investment of time and labor put into the research work necessary for the discoverey of new varieties, and better cultural methods is, of course, directly proportional to the extent that these improved varieties and methods are adopted and used by farmers.

So in 1911 a number of farmers of the state having been convinced of the value of this work, determined to form an organization for testing coöperatively with the Farm Crops Department the pedigreed grains developed at the Michigan Agricultural College.

An organization was formed and named the Michigan Experiment Association. Prof. V. M. Shoesmith of the Farm Crops Department acted as secretary of this association until 1917. During this period the organization grew from a few farmers to a membership of over twelve hundred, who were actively interested in experimenting with and growing improved grains.

The plan generally followed was to allow any member of the association to obtain from the station plats an amount of grain varying according to the supply, from one peck to one bushel. The member was then required to sow this seed beside his own variety and to report his results to the secretary of the association.

Varieties, of course, are not released from the station plats until they have proven their merit there, but we have such variable conditions of soil and climate in this state that we can scarcely expect to have a single variety of each kind of grain that will supercede all other varieties in every part of the state.

The coöperative testing has made it possible for the Farm Crops Department and the association to learn the special adaptation of various pedigreed varieties. For example, it was found by compiling the reports of growers

that the Worthy variety of oats was especially adapted to rich, heavy soil, and now this is probably the most extensively grown single variety in the state today. On the other hand, farmers reported that Alexander, a variety distributed at the same time as Worthy, and which gave practically the same results on the station plats, seemed to be especially adapted to the sandy loam types of soil, yielding better than most other varieties under these conditions.

In 1912 Plant Breeder F. A. Spragg released for distribution among the members of the association six pecks of Rosen rye. This variety instantly gave such remarkable results that for the next four years nearly all of the pedigreed grain produced from this variety was used for seed.

Until the fall of 1918 the demand for seed exceeded the crop of pedigreed grain produced during that season, and inasmuch as rye is a cross-fertilized grain and was often sown by farmers beside their common rye for comparison, we can readily see why much of the rye offered for sale as Rosen was not very pure.

Again it is universally acknowledged that heredity, while an important factor, is not the only one that must be cared for in the development and growth of all living things. Consequently we often find the best bred individuals in both the animal and plant kingdom failing to perform as illustriously as their ancestors when subjected to bad environmental conditions.

Under the conditions of supply and demand spoken above, which applies also to some other varieties of grain developed at the Michigan Agricultural College, we can readily conceive of the fact that some of this seed "fell on stony ground," and on ground that did not contain the plant food necessary to develop a crop of grain of good quality. While other seed was sown on land that was badly infested with noxious weeds, so, while the majority of farmers offered seed of good quality and condition for sale, some seed was placed on the market under the name of a pedigreed variety, which was of poor quality, contained weeds; was badly diseased, or in some other respect was not fit seed to give a good impression to the purchaser either at the time of purchase or at the following harvest.

Furthermore, the extension service, as now carried on by the United States Department of Agriculture and the Michigan Agricultural College coöperating, was in its infancy when pedigreed varieties were first distributed. Very few men were in the field explaining to the people the characteristics they should look for in a given pedigreed variety. Until the distribution of these pedigreed varieties was started, and even today, the average layman has never looked on plants in relation to their value as ancestors of succeeding generations.

The up-to-date farmer of today in his selection of the various kinds of live stock, considers the value and the advisabiltiy of the use of well-bred individuals of a few distinct breeds, which we find in general use in this and

all countries. But he is just beginning to realize the value of breeding in relation to crops.

Of course all those who have given thought to the matter concede that prolificacy, resistance to disease and adaptability to given conditions are all factors which can be greatly influenced by breeding, selection and cultural care of crops much the same as the efficiency of animals can be influenced by breeding and care. With farm crops forming the basis for most of the agriculture in this state and many other states, the surprising thing is that more effort has not been expended in the past years in the development, selection and standardizing of a few good varieties of each kind of grain.

With the advent and considerable distribution of pedigreed varieties in this state, the members of the Michigan Experiment Association came to the conclusion that some follow-up work was necessary beyond the mere releasing of a few bushels of improved varieties from the station plats, if these varieties were to become a permanent asset to the state. Moreover, the original purpose of the Michigan Experiment Association to experiment with and test the value of improved varieties had been attained, in that most of the members had come to the conclusion from their results that certain varieties were the kinds best adapted to Michigan conditions.

In order to make it possible for other people to profit by their experience, the members of the Michigan Experiment Association changed the plan of the organization to some extent in January, 1917, and reorganized under the name of the Michigan Crop Improvement Association. This organization includes in its activities the testing out of improved varieties and methods in coöperation with not only the Farm Crops Department, but also with other departments closely related with successful crop production, such as Plant Pathology, Bacteriology, etc.

This association does not confine itself alone to the testing of pedigreed varieties developed at the Michigan Experiment Station, but also seeks to ascertain on the farms of men interested the value of other varieties obtained through commercial sources, experiment stations of other states, and from farmers who have varieties that have given good results locally.

When after a number of successive years of testing out varieties in conjunction with the Farm Crops Department of the Michigan Agricultural College, a variety is found which is especially adapted to the given conditions, and this variety is of such importance that the association believes that other farmers should have means of obtaining genuine seed of that variety, it is made possible for farmers growing this crop to have their grain inspected by agents of the association in the field just before harvest and again after the seed is in storage.

The inspected seed requirements of the association are available to any one who wishes to write to the secretary for them, and these requirements are also furnished to each purchaser of inspected seed. These requirements

demand for most grains offered over 99% purity of variety practical freedom from noxious weeds and disease; must conform to a certain prescribed standard of germination, color, weight per bushel, etc.

The association does not handle orders or money for seeds, but merely directs the inspection work and publishes a list of the names of farmers whose seed conforms to the requirements. Then any one desiring seed of one of these varieties can obtain it direct from one of the men whose seed passes inspection, and this man furnishing the seed supplies a personal guarantee that this seed conforms to the inspected seed requirements of the Michigan Crop Improvement Association.

This association is not organized in opposition to or to take the place of legitimate seed companies. In fact, some of the larger seed companies of the state include as one of the large factors in their business the handling of pedigreed varieties.

Strict rules and expenses in connection with the association inspection necessarily limits to a few the number who will have seed conforming to the requirements but through the standards maintained for inspected seed; through genuine description put out in regard to them; through community and county grain shows; culminating in an annual grain show held by the association annually the first week in February in connection with Farmers' Week at the Michigan Agricultural College, it is possible for anyone to learn the characteristics of any one of the improved varieties and to obtain genuine seed of it.

To illustrate the value of the Michigan Crop Improvement Association in regard to the crop production of this and other states we might again consider some facts in regard to Rosen Rye. Of course, it is impossible to get accurate data in regard to a crop grown as extensively as this variety but the following data is based on as accurate information as there is available:

In 1912 one bushel of Rosen Rye from the Michigan Agricultural College was sown in Jackson county. All the Rosen in the state is descended from that bushel and a few additional bushels sent out from the station during 1913 and 1914. According to the records of the association about 200 acres were produced in 1915; 4,000 acres in 1916. In 1917 16,000 bushels passed the inspected seed requirements. In 1918 22,000 bushels passed. During these two years nearly one-third of the fields submitted for inspection failed to pass—most of them on account of mixture with common rye. Of course, the inspected seed represents only a small proportion of the seed sown.

Data gathered from growers, county agents, and dealers this last fall indicate that about 84% of the entire rye acreage of the state was sown in 1918 to more or less pure Rosen Rye. When we consider that the total acreage of rye sown was about 500,000 bushels, this represents a remarkable increase from the original bushel released in 1912. The popularity of this

variety has been based on the high yielding ability but it also has excellent milling qualities.

Seed of this variety has been sent in various sized quantities to over twenty-five other states. Over 5,000 bushels of registered inspected seed went out of the state last year. This represents only a small fraction of the amount sold out of the state by farmers, seed companies and others.

Rosen Rye is unquestionably the most sensational and valuable single variety yet developed by Plant Breeder Spragg, but the results obtained with other varieties of grain also show the value of standardization and more general utilization of a few improved varieties.

While the association continues its coöperative demonstrations with farmers with the various field, forage and soiling crops adapted to Michigan conditions, it hopes by its methods of introduction and inspection of improved varieties to see the day when instead of the hundreds of named varieties of different kinds of grain now to be found in this state, we will have a few standard, high producing, good quality varieties especially adapted to the given conditions of this state. A day when the farmers generally of this state will know the characteristics of these few standard varieties which best fit their needs; a day when a farmer will consider it an insult to his intelligence to try and lead him to believe that a dozen or two wonderful varieties of grain can be produced and distributed annually; a day when it will be possible for the people of this state to sell standardized products which will yield maximum returns for the time, labor and money invested.

Mich. Agr. College.

BOTANY.

THE MANUFACTURE OF SUGAR FROM *ARENGA SACCHARIFERA* IN ASAHAN, ON THE EAST COAST OF SUMATRA.

HARLEY HARRIS BARTLETT.

During a recent residence in Asahan, on the East Coast of Sumatra, the writer took a number of photographs illustrating the manufacture of sugar from the sap of the sugar-palm, *Arenga saccharifera* Labill., or, as it is less familiarly but more correctly known, *Arenga pinnata* (Wurmb) Merr. Although the essentials of the process have been frequently described, and are well known to botanists and ethnologists, the descriptions are in general too vague regarding local variations in procedure, which, if recorded, might prove of decided ethnological interest.

The population of Asahan is predominantly Batak. The chiefs trace their descent remotely from Toba, and the Asahan dialect is but slightly different from that of Toba. The majority of the people have been converted to Islam, and therefore call themselves Malays, for in the Batak lands, as elsewhere in the East Indies, the term Malay is more frequently used by the natives to denote religious than racial affiliation. All of the more prosperous and sophisticated natives are actual or nominal Mohammedans, but from the poorest to the richest, all, even the Sultan of Asahan, are of Batak blood. This statement disregards, of course, the thousands of contract coolies, Javanese and Chinese, who are employed on the great plantations.

Northwest of Asahan, on the coast, is the small district of Batoe Bara, where the inhabitants are undoubtedly of mixed Malayan and Batak origin. The chiefs, however, trace their descent from Menangkabau, and the social structure, with non-Batak division into four *soekoe*[1], or marriage groups, is like that of Southern Sumatra. Inland from this small Menangkabau colony, the contact of the Asahan Batak along their northwestern border is with the Simeloengoen Batak of Tanah Djawa. On the southwest they pass into the Toba Batak of Habinsaran, and on the southeast into the so-called Malays of Koewaloe, who, like the Malays of Asahan, are of Toba descent.

There has been considerable infusion of Malayan blood into Asahan from the trading points on the Asahan River, but it has probably been by no means as extensive as the Mohammedanized inhabitants like to believe. The present sultanate has at various times been claimed as a vassal state by both Atjeh and Siak, and the heroic epic of the Atjehnese, "Hikayat Malem Dagang," (1) which recites the exploits of the famous Radja Iskandar Moeda (1607-

[1]The Malay and Batak words used in this paper are spelled according to the system current in Netherlands India. The vowels have the usual continental pronunciation except that *oe* is equivalent to *u*. There are no peculiarities in the pronunciation of the consonants: *ng* has the sound of the same letters in the English word *singer*; *dj* is the English *j*; *j* is the English *y*.

1636) gives us an account of the conversion of Asahan to Islam, following the despoiling of the capital and the capture of the young queen of the pagan Radja. The poet uses considerable licence in locating Asahan on the coast of the Malay Peninsula, and in describing the paganism of the inhabitants as "sun worship practiced by them under the laws of Moses." There is little reason to doubt, however, that the epic gives a reasonably true idea of the beginning of the Malay tradition in Asahan.

The Malayan (Mohammedan) element of the population has absorbed immigrants from many sources, notably from the Mandailing region of Tapanoeli, on the West Coast of Sumatra, and from Bandjarmasin, in Borneo. The so-called Mandailing Malays, however, are of Batak blood, like the indigenes. It is impossible to make any estimate of the number of the Bandjarese, or of the importance of their influence on the native culture, because many Mohammedanized natives, of Batak descent, call themselves *orang bandjar*. Although this term is ordinarily used to designate the natives of Bandjarmasin, it is generally and correctly applied, wherever the Malay language is spoken, to dwellers in submerged river lands. (The geographic name Bandjarmasin means swamp lands inundated by brackish water.) *Bandjar* is also used in Sumatra, among peoples as distant as the Karo Batak and the *Orang Koeantan* of Indragiri to designate subsidiary or temporary agricultural settlements at a distance from the principal village of a jurisdiction. However, there are many Bornean Bandjarese in Asahan, as elsewhere on the East Coast of Sumatra, who have been enumerated as Malays. In Indragiri, south of Asahan, the census of 1916 gives the number of Bandjarese, from the South and East districts of Borneo, as nearly 19,000, out of a total population of 83,000. ([2])

The possibility of confusion in the interpretation of "*orang bandjar*" is worth noting in connection with the sugar industry, for the Bandjarese, as well as the Batak, are sugar workers. The sugar is sold as *goela batak* or *goela bandjar*, both names being used in Asahan, as well as the less significant name *goela itam* (black sugar). There is no reason to believe that the Bandjarese brought the art of sugar making to Asahan, for that it is a Batak industry of long standing is proved by its importance throughout the Batak lands. The art would seem to have spread to the Indonesian area from southern Asia, and to have been known longer in Sumatra than in the islands to the eastward.

If proof were needed that the sugar-palm has held an important place in the lives of the Batak since remote antiquity, it would be provided by the Toba myth recounted by Kruijt. ([3]) Si Boeroe Sorba Djati, they say, was a chief's daughter, who was to be married against her will to Si Radja Inda-Inda. To escape from the hated bridegroom, she jumped out of the house, and disappeared into the ground. The sugar-palm grew from that spot. The palm wine is her tears; the black fibres, her hair; the leaves are her ribs.

When tapping for palm wine, the natives often say to her, "Princess, have pity upon us, and increase your tears." No other tree is so completely invested with human attributes. Both Warneck (4) and Brandstetter (5) mention the fact that the Batak word for the sugar-palm, *bagot*, is the usual euphemism for a woman's breasts. In Toba, the carved representations of the female breast on the fronts of certain houses are called *bagot ni roema,* (breasts of the house). Only the closest association with this most useful palm would have led to its personification and to the invention of the Batak counterpart of the Daphne myth.

Aside from the uses already mentioned, the Batak use the roots of the *bagot* in basket making, the hollow trunk for drains, the hard, outer wood for flooring, the split midribs for laths, and the leaflets for thatch. The trunk is clothed with black fibres, *idjoek*, which make a wonderfully durable and sightly roofing material, and can also be woven into twine and rope. The longer fibers serve as strings for the native two-stringed lute, the *kasapi*, and the coarse, indurated ones for writing pens. If an altar (*andjapan*) is set up, where evil spirits are propitiated by offerings, the most conspicuous item in its construction is a feathery leaf of *bagot*. On occasions when the offering consists only of *sirih* (pepper leaf, betel-nut, lime, and tobacco, done up in quids, for chewing) it is stuck into notches in the midrib of a sugar-palm leaf, which is placed obliquely in the ground and adorned with certain magical apparatus. Such an offering is called *boeloeng ni bagot* (leaf of the sugar-palm).

From certain accounts of Arenga in other parts of Indonesia, it must be inferred that the tree is not planted, but utilized only where it is found wild. Such is not the case in Asahan, where it has a definite place in the simple crop rotation of Batak agriculture. It is likewise planted about the villages in the more densely populated Toba region. In the heart of the Batak lands, around the southern end of Toba Lake, agriculture is on a relatively high plane. Irrigated terraced rice fields extend as far as the eye can see, between the beautiful, island-like groves of bamboo, palms, and other useful trees, among which the villages are concealed. Between this densely populated region and the jungles of the East coast there are great stretches of rolling grassland, covered by various coarse, tall grasses called *lalang* in Malay. To one who has observed how these grasses occupy the land to the exclusion of other vegetation, when once they have invaded a cleared area, it seems not unreasonable to believe that the desolate *lalang* region represents the final scene in a cycle of changes set up by the destructive *ladang* agriculture about to be described.

For centuries the population of the highlands has been overflowing into the low, coastal belt. Here conditions have not favored the development of a dense population based upon permanent agriculture. Consequently the inhabitants show a cultural degeneration, as far as agriculture is concerned. Com-

bined with such high cultural characteristics as a general knowledge of reading and writing, in their peculiar character, we find almost as primitive an agriculture as one can imagine.

An Asahan plantation (*ladang* in Malay; *djoema* in the local dialect of Batak) is a clearing in the jungle, made by felling and burning. The first crop is always upland rice, which is planted in the soft, ashy ground, with no previous preparation, such as plowing. In fact, there is no such thing as a plow in Asahan, even on the great European plantations. The men and women walk side by side across the *ladang*, punching shallow depressions in the soft surface as they go, with long, blunt planting sticks. The children follow, and drop a few grains of rice into each hole. The seeds are not covered by the planters, but are left to be covered by the first rain. In the meantime, the *ladang* must be watched from a little watch house, where someone is constantly on guard, so as to drive away birds and animals. Scare-crows are used, all of them often connected with the watch house by strings or rattan, so that they can be kept in motion by the watchers.

Since the land is not cultivated, it ceases to be productive for rice, after a year or two. Then other plants are started, such as maize, red peppers, egg-plant, onions, ginger, Caladium, tobacco, and many others. These herbaceous types are interspersed with several kinds of bananas, manihot, pineapple, etc. In former days cotton was planted, which in that climate is of course arborescent. A few remnants of it are still to be found in out-of-the-way places. But regardless of what plants may be grown to prolong the utility of the *ladang*, its ultimate fate is reversion to jungle, unless, through invasion by *lalang*, it becomes irredeemable for native agriculture. The native has learned one way to turn the course of nature to his own advantage. He may plant his *ladang*, before he deserts it, with sugar-palm. The *bagot* will hold its own with any of the invaders which compose second growth jungle. It grows rapidly, and in ten or fifteen years becomes a productive sugar grove, and a source of considerable profit to its owner. It is interesting to note that the seeds of the sugar-palm are planted by the women, in order that they may be fruitful,—an example of sympathetic magic. Of course trees which occur spontaneously are also utilized. Blatter ([6]) states that the species seems to owe its wide distribution in Java to the fact that the corrosive fruit is eaten by two mammals, *Paradoxurus* (the palm civet) and the wild hog, *Sus verrucosus*. The same is doubtless true in Sumatra. Few animals are able to eat the fruit, which is of so acrid a nature that decoctions of it are said to have been used as a weapon by the natives in their early attempts to resist European aggression. The liquid was called "hell-water" by the Dutch.

With regard to the production of juice, it is hard to improve upon the statement in Logan's "Journal of the East Indian Archipelago," which has been quoted by several subsequent writers. ([8]) "Like the cocoa-nut tree, the Gomuti Palm (*Arenga saccharifera*) comes into bearing after the seventh

year. It produces two kinds of *mayams*, or spadices, male and female. The female spadix yields fruit, but no juice, and the male *vice versa*. Some trees will produce five or six female spadices before they yield a single male one, and such are considered unprofitable by the toddy collectors; . . . . others will produce one or two female spadices and the rest male, from each of which the quantity of juice extracted is the same as that obtained from ten cocoanut spadices. Each *mayam* will yield toddy for at least three months, often for five, and fresh *mayams* make their appearance before the old ones are exhausted; in this way a tree is kept in a state of productiveness for a number of years, the first *mayam* opening at the top of the stem, the next lower down, and so on, until at last it yields one at the bottom of the trunk, with which the tree terminates its existence." It should be stated that there is considerable irregularity about the distribution of the male and female flowers on separate inflorescences, and also about the regular succession of the inflorescences from the first one at the top of the tree, to the last one at the bottom. Barrett (7) has remarked on this matter, from his observations in the Philippines. However, the quotation is correct in the main. The earliest, and one of the best, descriptions of Arenga in botanical literature, that of Rumphius, makes clear the distinction between the two types of inflorescence, but calls the fruit-bearing one the male. Drude says of Arenga that the spadices are unisexual by abortion, but Blatter (6) states that this is not always the case, and quotes Brandis's statement (Indian Trees, p. 648) that most branches bear both male and female flowers. In Asahan Batak the fruit-bearing inflorescence is called the *halto*, and it is not tapped for juice. The male inflorescence is *meang ni bagot*. Before it is tapped, the peduncle, *botohon ni meang*, is pounded daily with a wooden mallet (*pambalbal*) for from three to seven days. This custom is so widely followed throughout the whole area in which Arenga is tapped that it is probably really beneficial, and not, as Barrett (7) suggests, a mere superstition. He tells that a tree which was being tapped for records of yield stopped flowing, for easily explicable reasons, but the natives (Luzon) attributed it to the natural resentment of the tree at being tapped by one who did not own it. That in the Philippines the beating of the peduncle may have become a mere ceremony, in the nature of magic, is indicated by Barrett's statement (7) that the peduncle "is beaten or whipped." Rumphius (8) knew the process of tapping the palm in Amboina, Bali, and Java, and mentioned the beating of the peduncle, as a regular part of the procedure. "Si racemus florens baccas aperire incipiat, crassus ejus caulis, ex quo dependet, per tres continuos dies levi baculo feritur, ut mollescat, sed simul, ne cadat, funiculo arboris ramo alligatur, qui tamen dependens tenetur; atque hac pulsatione succus, qui ad laesam fluit partem, allicitur." In Asahan the beating of the peduncle is often accompanied by a chanted admonition to the tree to be generous, but the old men were too bashful to repeat what they said, and I have not yet discovered whether or not

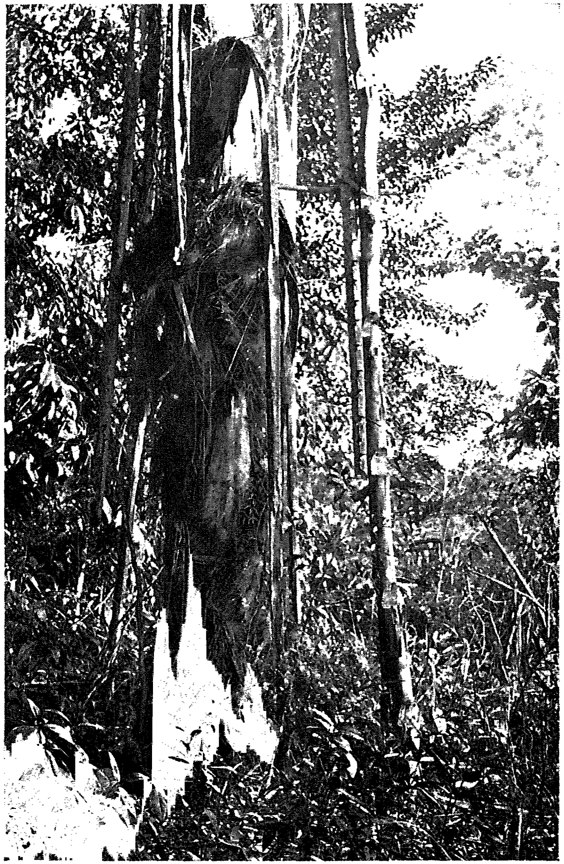
the song is included in the large collection which I brought back, but have not yet translated.

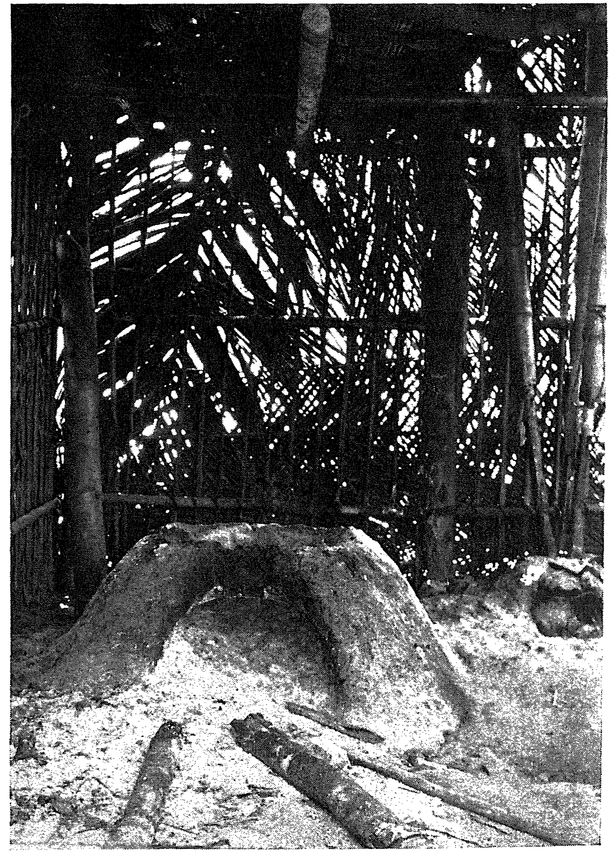
At the end of the days of preparation, the branched part of the inflorescence is cut off. The cut stump is then called *mata ni bagot* (eye of the sugar-palm) or simply *mata*. Twice a day the tapper (*maragat* in both the Asahan and Angkola dialects) visits the tree, to change the receptacle into which the juice flows, and each time he shaves a thin slice from the *mata*. After a day or so the juice (Asahan *nira* if used for sugar, *tocak* if used for toddy; Angkola *ngiro*) should flow freely. If it does not, something is wrong, and medicine (*oebat*) must be administered. If the *mata* is merely dry, but does not appear otherwise abnormal, the treatment called for is *tapak ni pat*, which, being literally translated, is sole of the foot. The *mata* is vigorously rubbed with the sole of the foot. The native's logic in rubbing the eye to bring tears may be considered sufficiently obvious, but why with the foot? It is a gymnastic performance which one might think would add considerably to the risk of a rather hazardous occupation. In Angkola the same condition is treated by rubbing with the fruit of a vine called *goppang batoe*. If the *mata* is yellow, it must be treated with leaves of a plant called *si torop* (*torop* means plentiful or numerous; *si* is the definite article, used before names) which yields a juice that blackens upon exposure, and causes the itch if it gets on the skin. If the *mata* is black-spotted, the medicine is an herb called *attaladan*, but if it is entirely black, soot from the bottom of the kettle (*birong birong ni hoedan*) must be used. In Angkola the treatment for the black condition is the same, the medicine being called *te ni parioek*. Barrett (7) tells us that in Luzon the flow of the inflorescence, when first cut, and each time subsequently, when a slice is shaved off, is stimulated by rubbing with the fruit of the red pepper, *Capsicum frutescens*. "Immediately thereafter," he says, "a greatly increased flow occurs, presumably influenced by the effect of the exceedingly penetrating principle of the peppers."

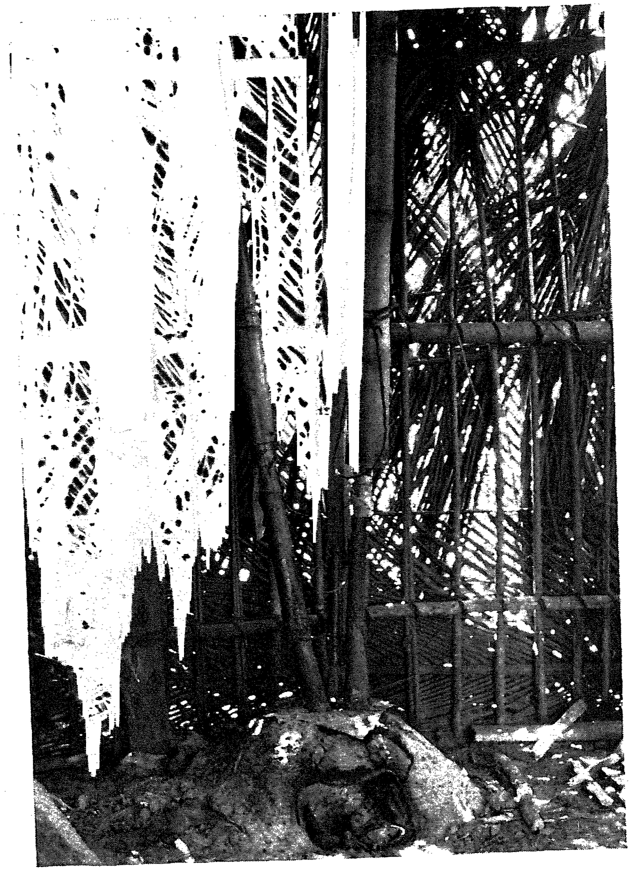
The juice is collected in bamboos, called *tagoek* in Asahan, and *garoeng* or *poting* in Angkola, the latter name applying to the larger ones. These are about four inches in diameter, and of various lengths from four feet to ten. Since such a long section of bamboo contains several nodes, the partitions must be knocked out, excepting, of course, the one that makes the bottom of the *tagoek*. The *tagoek* is never used twice in succession without being thoroughly disinfected. In a hot climate the saccharine juice, which likewise contains a considerable amount of protein, will begin to ferment very rapidly if mixed with even the slightest quantity of old juice, on account of the yeast and other organisms contained in the latter. Not only does a disagreeable taste develop, but if any considerable amount of the sugar is inverted, the product will not crystallize.

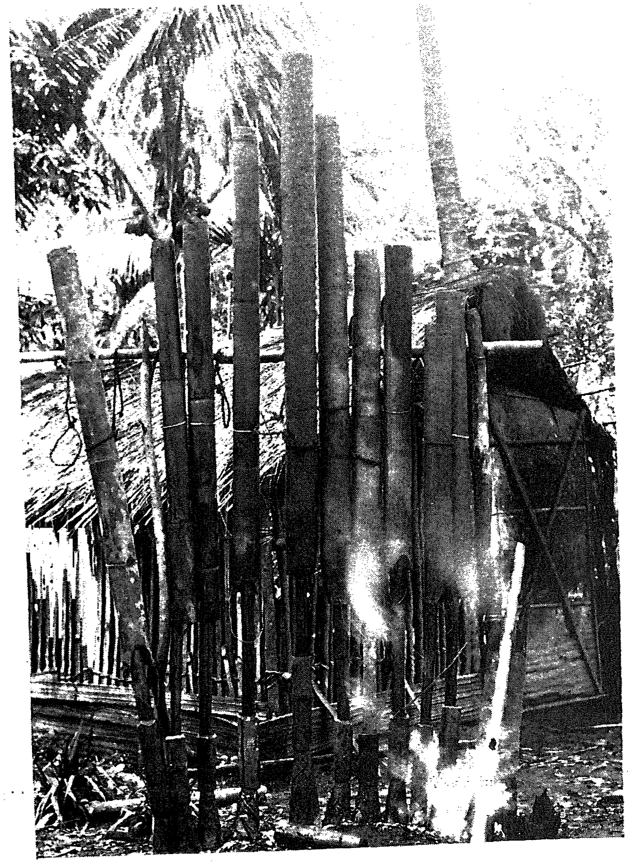
Sterilization of the *tagoek* is effected by smoke. I am informed by Marah Tigor Nainggolan, an intelligent native of Si Pirok, in Angkola, that in his

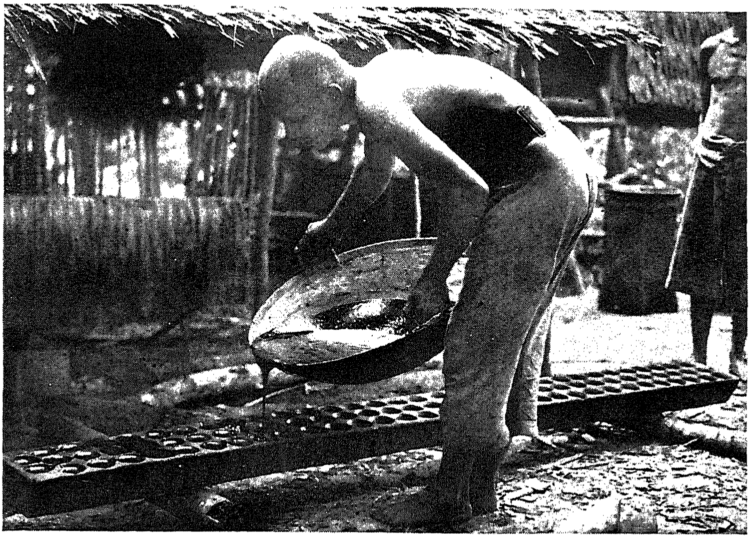
Plates 3, 4, 5, 6 follow Page 165











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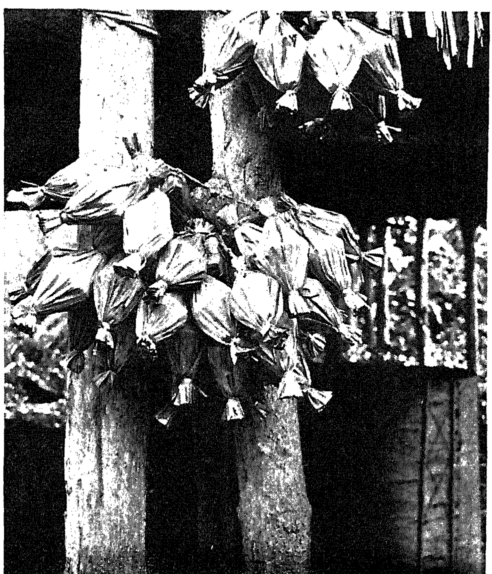

b

country hot water is used, a technical advance that may possibly be due to European influence. It is more likely, however, that it is a real native discovery, for we know from Tschirch (9) that in Java, which has been more thoroughly under European influence than any other of the Dutch East Indies, smoke was still used for sterilizing the bamboos about 1890. To smoke a *tagoek* it is turned up side down over a furnace and a smaller bamboo is used to convey the smoke from the fire to the very extremity of the closed end. The smoke pours out of the mouth of the *tagoek* after traversing its entire length. Either little individual furnaces are used for each *tagoek*, or else several of the bamboos are smoked over a furnace similar to that which is used for boiling down the juice. The contrivance shows a very intelligent application of a knowledge of the properties of smoke. It would be interesting to trace how far this knowledge extends among the less advanced natives of the Malayan region.

At the only Bandjarese sugar camp visited by the writer, at Kampong Koeboean, in Tanah Djawa, the bamboo receptacles for the juice had been replaced by five gallon oil tins, with a round hole in the side for the insertion of the peduncle. In spite of this evidence of progress in the path of civilization, the cans were being disinfected by smoking, in exactly the Batak way. Probably only the most advanced natives have experienced the advantages of using hot water.

The work of the *maragot* is difficult, and somewhat dangerous. Since the trunk of the *bagot* is rough, and difficult to climb, the inflorescence has to be reached by a ladder (*sige*), which consists at best of notched poles, lashed together, or of the upper parts of tall bamboo poles, from which the lateral branches have been cut off, leaving only stubs two or three inches long, to climb by. The collector has no responsibility for the actual making of the sugar. His duty ends with bringing in the juice: the rest of the work is done by the sugar-maker (*parbagot* in Asahan; *panggoelo or paragot* in Angkola).

The juice is boiled down in a large iron pan, about three feet in diameter, called *balanga* in Asahan, and *hoeali* in Angkola. This pan is set on the top of a hive-shaped clay furnace (*delihan*) which is moulded in wet clay, allowed to dry, and then burned hard by the fire used in sugar making. The furnace has one opening through the side, or two, on opposite sides, into which the fire wood is fed; the poles are not cut into short lengths, but are pushed further into the furnace as they burn off at the end. In Angkola the furnace and pan are together called *tataring*. To facilitate free boiling of the liquid, and reduce foaming, various hard nuts, or other objects, are placed in the pan, just as a chemist uses beads or bits of platinum in a boiling flask. The most commonly used seed is called *doelang-doelang* in both Asahan and Angkola; unfortunately it has not been identified. Another, the nut of a species of Aleurites, is the *djatoe* of Asahan, called *boewa keras* or *kamiri* in Malay.

When the consistency of the boiling liquid is such that it hardens when dropped into cold water, it is poured into the moulds. The latter are a series of holes carved in a plank from the exceedingly heavy, fine-grained, heart-wood of one of the jungle trees. The holes are accurately made, and highly polished. Before the boiling syrup is poured into them they are wet with cold water, so that the cakes of sugar will not adhere to the wood. The set of moulds is called *toeangan*, and as far as my information goes, it is characteristic of the region. The cakes of sugar have the shape of a truncated cone, a couple of inches across the base. Each one is a *kotoel*. They are done up in packages of two, with the bases together, and are wrapped in a banana-leaf package (*tiroesan*) which is so skillfully put up that it is practically air-tight. The sugar is very nicely preserved as long as it is hung up, preferably in the smoke, where the wrapper is not punctured by insects, but if it is exposed to the moist air, through the smallest opening, it quickly deliquesces.

In Karo-land the sugar is cast into flat cakes, three or four inches in diameter and a half-inch thick, of which a considerable number are done up in a large banana-leaf wrapper. This is true also in Toba and Angkola: in the latter district the individual cake is called *sagindar*, and the package *boekkoesan*. At the Bandjar sugar camp in Tanah Djawa, mentioned above, flat cakes were also made. The moulds were bamboo rings, cross sections of a large internode, about three-quarters of an inch high. They were placed upon a flat plank, which formed the bottom of the mould. Before the syrup was poured, both plank and rings were wet with water.

In spite of the importance of Arenga sugar to the natives, there has been no systematic attempt thus far to utilize the tree in European colonial agriculture. Junghuhn's "Java" (the author lived in Java for many years about the middle of the last century) is quoted by Tschirch (9) to the effect that in six mountainous districts of the residency Bandong, at an altitude of from 2,500 to 3,500 feet, there were 1,585 persons occupied in making palm sugar, with 159 cooking places and 335 iron pans. Of the trees, 3,200 were not tapped; 12,900 were beginning to yield, and 4,700 were in full tapping. The production was about 1,970 pikols. (A pikol is about 133 pounds.) The meticulous exactitude of the statistics regarding a native industry was most astonishing to me until I ran across a remark of Veth (10) showing that the thrifty administration of those days enforced the delivery to the government of all the palm sugar produced, at a rate of florins 1.50 to 1.90 per pikol. But notwithstanding the importance of Arenga to the natives, it has been neglected as a possible source of sugar for commerce. It is true that at the Marseilles Exposition of 1906 an effort was made to interest the trade in the Arenga sugar of French Indo-China, but with no success. (11)

In the Philippines, Barrett has taken much interest in the possibilities of palm-sugar. In one paper (7) he states that one hectare (2.47 acres) planted with 150 to 200 trees, should produce 20 tons of sugar per year for a

period of ten or fifteen years, a yield comparing favorably with that of sugar cane. Elsewhere ([11]) he calculates the yield from the palm at twice that from cane. Sixty, eighty, or a hundred trees to the acre can be planted. Each tree yields from five to eleven liters of juice twice a day, of which the sugar content is 15% to 16½%. Opposed to this estimate for the Philippines is that of Tschirch, ([9]) for Java. This writer estimated the yield at about four tons per hectare per year, and concluded that Arenga would be an unprofitable crop. But quite regardless of the future of the palm sugar industry, it cannot fail to be of interest to us on account of its antiquity. It has existed for centuries among peoples whom we are accustomed to look upon as having a very low culture. Nevertheless, these same peoples of southeastern Asia and the adjacent islands doubtless invented the art of making sugar. The evidence points to Cochin-China, India, or Indonesia for the original home of the sugar cane, which is known only in cultivated forms, and of which the almost complete sterility affords presumptive evidence of a long history since it originated from an unknown wild prototype. The art of sugar manufacture spread westward, first through the agency of the Arabs, during the Middle Ages, and then of the Portuguese and Spanish, to whom we owe its wide dissemination through the American tropics. Aside from honey, however, the northern European races developed no source of sugar of their own until beet sugar was discovered by Marggrav in 1747, and it was nearly a century before this discovery led to the firm establishment of the flourishing beet sugar industry of today.

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BIBLIOGRAPHY.

1. Hikayat Malem Dagang. An English summary of this epic will be found in "The Achenese" by C. Snouck Hurgronje, translated by A. W. S. O'Sullivan, (Leyden, 1906) Vol. 2, pp. 80-88.
2. Encyclopaedie van Nederlandsch-Indië, ed. 2, 1918. (Article "Indragiri.")
3. Kruijt, A. C. Het animisme in den Indischen Archipel. ('s Gravenhage, 1906.) See p. 153.
4. Warneck, J. Tobabataksch-Deutsches Wörterbuch. (Batavia, 1906.)
5. Brandstetter, Renward. Malaio-polynesischen Forschungen, Zweite Reihe, III. Prodromus zu einem vergleichenden Wörterbuch der malaio-polynesischen Sprachen. (Luzern, 1906.) See p. 70.
6. Blatter, E. The palms of India and Ceylon, indigenous and introduced. Journ. Bombey Nat. Hist. Soc. 22:444-463. 1913.
7. Barrett, O. W. The sugar palm. Philippine Agric. Review 7:216-221. 1914.
8. Rumphius, Herbarium Amboinense, pars prima, pp. 57-64, tab. XIII.
9. Tschirch, Alexander. Indische Heil- und Nutzpflanzen und deren Kultur. (Berlin, 1892.)
10. Veth, P. J. Java, geographisch, ethnologisch, historisch. (Haarlem, 1875.) See eerste deel, p. 564.
11. Barrett, O. W. Some new or little known Philippine products. (Abstract with discussion.) Proc. 3d Internat. Congress Trop. Agric. (London, 1914.) pp. 349-352.

EXPLANATION OF THE PLATES.

Plate III. a. *Arenga saccharifera* Labill. (*Bagot.*) Upper part of a tree, showing the enormous fruiting inflorescences (*halto*), and, lower down, on the left, the severed peduncle (*botohon ni bagot*) of a male inflorescence (*meang*) from which is suspended a bamboo container (*tagoek*) for the juice (*nira*). The collector (*maragot*) is in the tree at the right of the inflorescence which is being tapped.

Plate III. b. Interior of a sugar grove, showing the rough trunks of the *bagot*, clothed with the sheaths of dead fronds and with the black fiber known as *idjoek*.

Plate IV. a. Base of a *bagot* showing the ladder (*sige*), made by lashing notched poles together with rattan.

Plate IV. b. The hive-shaped clay furnace (*delihan*) over which the juice is boiled down in a large iron pan (*balanga*).

Plate V. a Smoking bamboo containers over a small furnace similar to that used for boiling down the juice. The large *tagoek* is inverted, and into it is passed a smaller bamboo which conducts the smoke from the furnace. Yeasts and other microorganisms are destroyed in this way after each use of the container. The *tagoek* on the right shows the rope, woven from *idjoek* fiber, by which the *tagoek* is suspended from the *meang*.

Plate V. b. The process of smoking containers over small, individual, conical furnaces made out of sheet iron.

Plate VI. a. Pouring the melted sugar from the *balanga* into the mold (*toeangan*). The mold is first wet with water, so that the truncated cones of sugar (*kotoel*) will come out readily.

Plate VI. b. Packages of sugar ready for market. Each package (*tiroesan*) consists of two *kotoel* wrapped in banana leaf.

All of the plates are from photographs taken by the writer in Asahan. Figures IIIa to Va show scenes at a sugar camp on the path from Kampong Ajer Teloek to Ladang Si Djaboet. The photographs for figures Vb and VIb were made at Silo Maradja, and that for plate VIa at Mariadoge.

MICHIGAN—AN IMPORTANT SOURCE OF RAW VEGETABLE PRODUCTS.

HENRY KRAEMER.

In the practical development of industry and commerce, there are two viewpoints, and there are necessarily two classes of students. Those in the one group, consider only what is established and demonstrated by previous experience. In the second group we find those who venture somewhat ahead of present day practices. During times of peace, the capitalist keeps pretty close to the shore line of conservatism. He listens only to that inventor or originator who has demonstrated peradventure the practicability and plausability of a project. It is in time of war that the resourcefulness of a nation means victory for her armies; then it is that the men of initiative, the experimenters along original lines, are called in for assistance. The efficiency of the enemy must be met by higher efficiency if victory is to be won. As soon as a problem is announced it must be solved to avert destruction. During the war we saw how gas offensive was met by an equal defensive, followed almost over night by a higher offensive which spelt final disaster to the foe. The whole store of the ingenuity displayed by the Allies has not reached us, but we do know that the war changed the conservatism which is ordinarily displayed into a spirit of venturesomeness which has never been surpassed. Natural resources were developed in a spectacular fashion. Nature's forces were harnessed in an almost superhuman manner, and human efforts were coordinated in unity of purpose to a degree which no one would have prophesied. The war showed, furthermore, that that nation that had command of the largest quantity of raw material, or that could synthetically reproduce it, would win the contest. The enemy found that if the nitrates of Chile were denied her, she must develop processes to derive them from the air; and if the cotton of the United States could not reach her, she must manufacture the supply from her forests. In the same way we found that if we could not obtain potash from the mines which formerly supplied us, we must either discover new sources in nature or devise special processes for the recovery of this element. In the case of lubricants, where the shipments from other countries were slow and uncertain, the government did not hesitate to plant thousands of acres of the castor-oil plant, which would give us an independent harvest. Probably the most remarkable industrial achievement during the war was the production of the inert gas helium, used in balloon work, at a cost of 10 cents per cubic foot, when the pre-war price was about $1,750 per cubic foot. At each point, lack of supply was met by a high order of resource-

fulness which made for productivity equal to the needs required. Those who have any knowledge of the situation which confronted us at the time of our entry into the war, knowing how each need was met on a fairly lavish scale, will no doubt be willing to admit that, with regard to the material necessary for carrying on the war, we were prepared to meet every exigency. In connection with this development new industries were created, and some which had been experimental in the past were established on a commercial basis. Among the newer phases of activity thus developed, none was of greater interest than our ability, independently, to produce and manufacture the medicines which were deemed necessary by our army.

One of the most fundamental questions which we must consider almost immediately is to what extent we should relinquish the vantage point we have attained and go back to our pre-war practice of depending on foreign countries for not only raw but manufactured materials as well. I may not be a prophet, but I have sufficient optimism to believe that the old dependent conditions will not prevail, and that manufacturers realize that in the interest of our country we must be more independent of other nations. At the present time trade and industry are in an unsettled condition, and large projects are not being undertaken to any extent because peace has not yet been actually established. I have seen figures of the contemplated improvements in various projected enterprises which are of a gigantic character, and we feel that we are approaching a new era in which the pioneer will work with the capitalist, and in which a truly rational condition will prevail.

For some years now I have felt that it was desirable for us to cultivate very many if not all of the really important medicinal plants. This principle is sound and tenable; in the interest of uniformity of drugs and progress in the action of medicines. Furthermore, our supplies are becoming depleted, and in some cases are even now almost exterminated. It is important that we understand the extent of the problem and the object to be attained in order that we may attack it in an effective manner. I think that it is largely due to our lack of perspective that we have not made greater progress. Of course, it is always necessary in a new venture to make a demonstration of facts to support the thesis. I have called attention (*American Journal of Pharmacy*, 1918, Vol. 80, pp. 404-415) to what was accomplished during the war. What may further be undertaken can be determined only by experiment. The history of the cultivation of plants yielding industrial products is rather anomalous. For instance, there are certain plant products, which it may seem for the moment are confined to certain geographical centers, as the growing of cinchona, rubber, coffee and spices. Yet even these are being more widely known constantly for commercial reasons, and at present it is rather difficult to tell just which countries are producing our commercial supplies. The original home of cinchona was in South America, and it is only recently that any attempt has been made to restore this industry to this part of the world.

Furthermore, were we dependent upon the native cinchona tree of South America for our source of supply of quinine, this alkaloid would be not only of prohibitive price, but so rare as to make it a museum specimen. This would be a dire calamity, as quinine is one of the alkaloids that would be exceedingly difficult for us to make synthetically at a fairly reasonable price. All of the commercial cinchona is obtained from trees cultivated in the East Indies, British Indies, Mexico and Northwest Africa, and there is just a possibility that it might be cultivated in certain parts of California. The coffee tree, originally of Abyssinia, and at one time almost solely cultivated in the East Indies, is now an important article of export from South America, Brazil sending us not less than 600,000 tons annually. The spice trade, originally confined to the Dutch East Indies, has been extended to the West Indies and other tropical countries. Until the last edition of the United States Pharmacopoeia (1916), Cannabis Indica was derived solely from plants cultivated in India. The Indian government placed an export duty upon this product, and in a remarkably short time we were importing a high-grade drug from Africa, Asia Minor, Turkestan, France, Italy, Spain, Mexico, and almost simultaneously we found that we could grow an exceptionally active drug in the United States.

During the past summer, at the Botanic Gardens of the University of Michigan, there were grown about fifty different medicinal plants, and while one year ago no one could have prophesied what the returns might be, yet they all grew abundantly, the drugs obtained from them being in some instances of an unusually high grade. Many drug-yielding plants are used also in other industries, and often in greater quantities than in their medicinal use. For instance, some of these, as Cannabis, furnish stems which are of considerable value, yielding, as you know, the hemp fiber. The "braking of the hemp" was at one time practiced in Michigan, and there is apparently no reason why the product here should not be equal in quality and value to that product in Kentucky. Again, there are the poppy capsules, which yield an abundance of an oily seed used in baking. The lavender flowers and marigold plants can be made into a fragrant pot-pouri, etc. The results of these experiments, begun last summer, have caused us to view this work in its broader aspects and have widened the scope of our investigations, as indicated in the title of this paper.

The conditions in Michigan seems to show that we enjoy a very productive climate, and this, taken in conjunction with what has been done, would seem to indicate that we enjoy certain natural advantages which justify more experimentation and operation on even a greater scale. It is interesting to run over some of the statistics from the United States Census for 1910 on the value of raw products obtained from Michigan:

BEET SUGAR.

Value of products	$10,476,876
Value added by manufacture	4,249,278
Total	$14,726,154

CANNING AND PRESERVING.

Value of products	$4,970,911
Value added by manufacture	1,896,991
Total	$6,867,902

FLOUR AND OTHER GRIST MILL PRODUCTS.

Value of products	$34,860,803
Value added by manufacture	5,501,392
Total	$40,362,195

LUMBER AND TIMBER PRODUCTS.

Value of products	$61,513,560
Value added by manufacture	32,471,918
Total	$93,895,478

ESSENTIAL OIL.

Value of products	$486,159
Value added by manufacture	71,077
Total	$557,236

WOOD DISTILLATION.

Not including Turpentine and Rosin.

Value of products	$2,398,927
Value added by manufacture	1,243,578
Total	$3,642,405

CHICORY.

Amount of Chicory	19,204 000 pounds
Value of product	$70,020
All other states, value of product	$80,000

GINSENG.

Value of product (sixth state in production)	$13,794

MINT.

Value of products	$194,391

BROOMS.

Value of product	$417,940

PULP WOOD.

Value of product	$858,280

POTASH FROM WOOD ASHES.

Value of product	$12,890,000

These figures of course are not up to date and do not furnish us their real significance. For instance, most well-informed people in the United States have heard of Kalamazoo celery. Few people probably realize that among the trade in essential oils throughout the world, the Kalamazoo mint oils are held in equal esteem. The trade in ginseng of Kalkaska County and the chicory of Isabella County is also of great value. All of the slippery elm bark used in medicine and the arts is gathered in Michigan. There has been a wonderful development during recent years of the crude drug industry in Michigan and judging from the advertisements in the trade journals and my own knowledge of what is being accomplished, it is destined to surpass North Carolina, which has held precedence for nearly a century.

THE DRUG PRODUCTS OF MICHIGAN.

One of the most interesting observations in this connection is the fact that many of the plants growing in abundance in our native woods are among the most valuable from a medicinal and economic point of view. In addition to the sugar maple, which is widely distributed through the state, we may note among the common trees and shrubs of considerable commercial interest the following: The sweet or black birch, which yields a volatile oil resembling wintergreen; the balsam fir, which furnishes an oleo-resin that is used exten-

sively in making permanent mounts of objects for examination under the miscroscope; the hemlock, the bark of which is extensively used in tanning; the several spruces, which furnish a gum used chiefly in the manufacture of chewing gum; dogwood, witchhazel, black cherry, prickly ash, sassafras, white oak, the barks of all being of medicinal interest. The list of herbaceous plants, including golden seal, blood root, mandrake, wintergreen, etc., is too long to be included here, and would contain nearly all of the important official articles collected in the United States.*

The principal object of this article is to present a summary of last year's experiments in the growing of medicinal plants at the University of Michigan Botanical Gardens. These experiments, taken in conjunction with the rather extensive farms already established in various parts of Southern Michigan, seem to show that this state is destined to become one of the great drug-producing states in this country. In manufacturing pharmacy, she holds first place. Probably one-half of the medicines used in the United States are the output of the manufacturing laboratories located in Detroit alone. At the present time there is a greater acreage in Michigan devoted to the cultivation of medicinal plants than in any other state. The story of the peppermint industry in Michigan affords one of the most interesting chapters in the development of our natural resources. By the application of industry and the ability to form rational conclusions, followed by simple field experiments, the mint industry has been developed, adding wealth and honor to the pioneer and enriching those who were willing to duplicate his experiments.

The interest in the cultivation of medicinal and economic plants began with the early settlers. Hops may be considered the first medicinal plant to be grown in the United States. It was first grown in Virginia, but with very poor success. Later it was found that a colder climate was better suited for the growth of the hop plant and the cultivation was taken up by some of the farmers in New England. It was then introduced into New York state and later into Michigan, and some of the other middle and western states. It is from these states that our commercial supplies are chiefly obtained.

It is not always easy to determine what plants can be successfully grown in any given locality. Only actual field tests can give the correct data. Failure, while it has a practical significance, acts only as a stimulas to the pioneer. There are indeed very few plants that have not become established

*The following are some of the works dealing with the Flora of Michigan, all of which are in the Library of the University.

Beal, W. J. Michigan Flora. Published by the Michigan State Agricultural College, 1892.

Beal, W. J. Michigan Flora, a list of the fern and seed plants growing without cultivation. Published by the State Board of Agriculture, Agricultural College, Michigan, 1904.

Farwell, O. A. A catalog of the flora of Detroit. Reprinted from the second annual report of the Michigan Academy of Science.

Otis, Charles H. Michigan trees. University Bulletin, v. 14, No. 16, 1913.

Transeau, E. H. The bogs and the bog flora of the Huron River valley. Reprint *Botanical Gazette* 40: 351-375, 418,448, 1905, and 41: 17-42, 1906.

Wheeler, Charles F. and Smith, E. F. A catalog of the Phaenogamous and vascular Cryptogamous plants of Michigan.

in other localities than those in which they are indigenous. One of these is the Venus' Fly Trap, which has not been successfully established outside of its home in the vicinity of Wilmington, N. C.

The experiments with the hop plant have been duplicated with other plants, especially those of the mint family. The peppermint industry was first developed in Wayne County, New York, and later taken up in Michigan, Indiana, Ohio and other states. By reason of the more favorable climate and soil conditions, the peppermint industry in Michigan has outstripped that of the other states. The total amount of peppermint and spearmint oil produced annually throughout the world is about 600,000 pounds. At the present time nearly one-half of this is produced in the United States, Michigan producing the largest proportion. It is not merely due to the fact that the muck lands of Southern Michigan are specially suited to the development of these labiate plants, but also to the fact that the growers in Michigan have invested considerable capital in the business, and have provided themselves with an equipment which enables them to handle the distilled oils in an economical manner. The cost of operating an acre of mint and caring for it during the first season is placed at about thirty dollars. This is cut about one-half in subsequent years. The yield of green herb is about 30,000 pounds per acre, and this will give on distillation, under the most favorable conditions, about 100 pounds of oil, which will bring about two hundred and fifty dollars in the trade.

In Ecclesiasticus it is written that "the Lord created healing herbs out of the earth and a prudent man will not cast them aside." The origin of the use of medicine goes back to antiquity, and there are records which show that some of the important medicinal plants were cultivated since first their value was known. With the exception of the important farm products there have been but comparatively few plants cultivated for medicinal and industrial uses. Throughout the world nearly all of our crude drugs and commercial supplies of very many economical products are still obtained from wild plants. From the fields and forests of the United States enormous quantities of useful products are obtained. It would be rather difficult to give an exact computation, but somewhere from twenty-five to fifty per cent of the raw material used in the arts and medicine are derived from plants growing in our country. The remaining supplies are imported from nearly every part of the world. It may be too much to expect that we can ever become entirely independent of all other countries for our raw materials, but the lesson of this war teaches us that we should take every precaution to provide against our being too dependent and thus seriously handicapped when for any reason these foreign supplies are cut off. This situation would be greatly improved if by mutual agreement with other nations as to the exchange of drug materials. History shows that monopolies of medicinal supplies often give rise to prohibitive prices, much to the discomfiture of the trade and greatly to the detriment of the public.

Some thirty-five years ago an effort was made to have the United States Department of Agriculture carry on experiments which would ultimately lead to the introduction and cultivation of very many foreign medicinal plants. It was not, however, until 1913 that through the reorganization of the Bureau of Plant Industry, United States Department of Agriculture, was instituted a special department for the study of drug yielding plants. This department has since then conducted experiments on a number of both native and foreign drug-yielding plants. There has been a divided opinion in this country as to the possibility of cultivating medicinal plants and placing this industry on a paying basis; in fact, there has been a prejudice against seriously considering this subject in a practical manner. No doubt some of this sentiment was started in the interest of those who were exporting drugs to this country. Fortunately, however, some ten or twenty years ago there were those who recognized that our supplies of native plants were being reduced as well as becoming of inferior quality, and attention was directed to the necessity of providing for future supplies through drug farming. Of course, sporadic attempts had been made to grow medicinal plants in this country, but, with the exception of ginseng, the attempts could hardly be termed successful. Valerian was grown in Vermont, licorice in New Jersey, saffron near Lebanon, Pa., but these efforts were of hardly more than local interest. Mrs. Gene Stratton Porter's book, "The Harvester" appeared at a psychological moment, and to a remarkable degree influenced business men to consider seriously this question. In the meanwhile experiments had been conducted which showed that cultivated plants were, if anything, more efficient than wild plants, and with the acceptation of this theory a few manufactures were ready to farm a certain number of medicinal plants. The war situation brought us face to face with a possible scarcity of a number of valuable crude drugs, and with the experience which we have been gaining we have been rapidly building up this new industry. The question which is giving me some concern is, will we continue under normal conditions to develop this industry or will we allow it to lapse, losing the impetus which we have thus far acquired, leaving it to another generation to work it all over again?

The greatest obstacle in our developing drug farms has been the high price paid for labor in this country, and the fact that we did not know how to grow medicinal plants and harvest them so as to meet the foreign conditions, where low price labor prevails. Since the war many of the foreign sources for crude drugs have been cut off, and the prices soared so high as to make the cultivation of several medicinal plants very profitable. Indeed, it has been possible to raise crops valued at from one hundred to one thousand dollars per acre. It is quite likely within the next year or two that we will again be supplied with foreign drugs or they will be offered for sale, and the question will be whether we can grow and harvest our own drug-yielding plants and market them at a price to compete with those obtained from foreign

sources. It is quite likely that a number of those who have started drug farms will be discouraged, as the market prices for crude drugs will come down from fifty to seventy-five per cent. In other words, the prices will approach more nearly normal conditions. There are two things necessary to make drug farming a success in the United States. The first is, that the most economical conditions must be worked out for growing the plant and harvesting the drug. The second is, that that sufficiently large farms must be developed so as to make it profitable for the farmer. The profits in most cases, no doubt, will be greater than in ordinary truck or produce farming, but the permanent returns cannot be expected to compare with those which prevail at present. It was partly with the view of helping the situation, especially in Michigan, that experiments were conducted this year at the University of Michigan College of Pharmacy, under the direction of the author.

Some 20,000 medicinal plants were grown, representing more than fifty different species. Notwithstanding all of the difficulties that naturally beset such an experiment in its early stages, including the great variations in seeds and the difficulty of securing labor, the loss of plants was so small as to be practically negligible and the crops from nearly 15,000 plants were harvested, the remainder being left in the field. The facilities for drying such large quantities of material were inadequate, and the floors of the lecture and laboratory rooms of the Science building and the attic or loft of the Chemical building had to be utilized for drying the crop.

Of all those who have written upon the subject of the cultivation of medicinal plants in this country almost no one has had the vision to see the possibilities of this new industry, and for the most part all efforts have been directed toward discouraging rather than encouraging the enterprise. One of the chief objections which has been raised is that the amount of drugs used is so small compared to the enormous amounts of foodstuffs. For instance, it is estimated that the amount of belladonna which would be used in the United States could be grown on about three hundred acres. While this limitation may be true of quite a number of our medicinal plants, yet it must also be borne in mind that some of these drug-yielding plants have very great uses outside of the field of medicine. As an illustration of this, we may refer to the castor oil plant, the seeds of which yield a fixed oil commonly known as castor oil. It would seem reasonable that the output from five hundred acres should yield all the castor oil which is used in medicine in the United States. But its uses in this manner are infinitesimal compared to its use as a lubricant for fine machinery. During normal times we import over one million bushels of castor bean per year, the oil being extracted by vegetable oil crushers in the United States. So dependent was our government during the last year of the war on the supply of caster oil as a lubricant for the motors of aeroplanes that it made arrangements in the southern states for the planting of one hundred thousand acres of the castor oil plant. The problem with this industry is not

one, then, of small acreage, but of placing it on a basis to compete with the lower cost of labor in India. In fact, even at the present time the oil crushing interests of the United States have taken steps to see that the government develops a post-war policy which will not place the American crushers at a serious disadvantage.

With the advent of every new problem there are fortunately a few who are willing to venture and to have faith in their experiments, but there are also a great many good intentioned people who are unable to see what has not as yet been demonstrated. Many of them are like the man who sees the forest at a distance; to him it seems like an adamantine wall, and unfortunately, he never gets close enough to see the path which lies between the individual trees. It is the man who gets right down to the problem that sees the light and makes the clearing and does something for humanity. It reminds one of the days of Watt, when he was introducing the steam engine; some one suggested: "What if a cow should get on the track?" To this he serenely replied, "It would be bad for the cow." In addition to some of the objections already pointed out, there are those who fear that there is sure to be an over-production of some one crop, and that this will be followed by a lot of attending evils. The man who is intelligent enough to farm medicinal plants is likely to possess sound judgment. The farmer who is growing a hundred acres of corn today is not likely to plant another hundred in sweet marjoram, or dill, or some other crop which is used as a pot herb. In other words, these matters will all right themselves, and possibly even new industries may develop as a result of this over-production. The fact is, if we can get the pioneer on the soil of opportunity, he will develop it to its utmost. Possibly it might be well at this time to give the real story of the origin of the peppermint industry in the United States, which is not generally known. About seventy-five years ago there was a Yankee peddler named Burnett who went through the country districts of Connecticut, Massachusetts, Vermont and portions of New York. He peddled tin pans, rugs, chromos and other things that the housewives on the farms very much coveted. The women had not a great deal of money, so he hit upon a scheme of exchanging herbs in lieu of money for his merchandise. When you think of it, you will see that, though unlettered and untutored, he understood all of the arts of the salesman, and was more than a merchant, being something of a financier. He realized that herbs were good collateral and had their standard market value. Anything which can be marketed is money. You will perhaps recall that black pepper and the other spices were used as money at one time. In the course of his travels he secured large quantities of peppermint. It occurred to him that he might distill the oil, and so he constructed numerous stills, especially in Wayne county, New York. He then gave up his peddling business and occupied himself in collecting and distilling the mint and selling the oil to the country dealers.

At this time not more than 200 kilos of peppermint oil were produced in the United States. Seeing the success of Burnett, a dealer by the name of H. H. Hotchkiss became interested in the peppermint oil industry. He had a little country store in the village of Phelps, Ontario county, New York. He had obtained quite a quantity of oil of peppermint from the farmers, who were distilling the oil in a small way, and delivering it to Mr. Hotchkiss in payment of merchandise. It occurred to him that as he had a standard product, he would endeavor to obtain a wider market. So he stocked the oil in tin cans and took a sample to New York. Not one of the drug dealers would touch it, as they claimed it was not pure oil of peppermint. Knowing that his oil was pure, and finding that Hamburg, Germany, was the great center for the distribution of volatile oils, he thought over the situation and decided to open up negotiations with one of the foreign firms. Though but a little storekeeper, he went at his task in a most thorough manner. He further satisfied himself by giving careful attention and inspection to the plants of those who were distilling the oil and was further satisfied that the oil was not only pure, but equal to that produced anywhere. He made a special container, using the old-fashioned 21 ounce lip-mouthed ink bottles. He then had a special label printed, which read:

Peppermint Oil from Wayne County, N. Y., U. S. A.
Guaranteed pure by H. G. Hotchkiss.

The bottles were neatly capped and sealed and samples were sent to a firm in Hamburg. Later a large consignment was sent to the same firm. Mr. Hotchkiss stated that he should receive $1,000 if the oil was accepted. He heard nothing from the firm for a long time and then received a draft for the sum demanded, with an order for another consignment of peppermint oil. This was the beginning of the development of a new industry, namely, the peppermint oil industry of the United States. He gave up his country store and went into the growing of peppermint and the distilling of the oil on an extensive scale. Mr. Hotchkiss' success was the talk of the day among the farmers of Wayne county, who followed his example and made Wayne county famous for its oil of peppermint. The farmers realized about 25 pounds of oil to the acre, and at that time they were receiving from $2 to $5 per pound.

The early story of the peppermint industry in the state of Michigan has been well written up by Frederick Stearns, the founder of the firm of Frederick, Stearns & Co. of Detroit. It is published in the *American Journal of Pharmacy*, 31, pp. 33-35, 1889. Peppermint was first introduced into St. Joseph county in 1835 by Calvin Sawyer, who brought the roots from Ohio, and made the first plantation on Pigeon Prairie, in the township of White Pigeon. In the spring of 1836 two farmers, named White and Earl, procuring roots from Calvin Sawyer, made plantations on the same prairie, and in the same township. In 1837 the number of plantations was increased by others, and in 1838

Marshal Craw and Lewis Ranney commenced its culture on burr oak soil, in Florence township of the same county. In the soil of these burr oak openings, as they are termed (being rich, loamy and gently undulating, covered here and there with a scant growth of the burr, or scrub oak), the mint was found to produce better than on the prairie soil, where it required more labor to cultivate it. On the prairie soil it was often unprofitable, due to the winter-killing of the roots, occasioned by the exposing of the soil to frost in level places, from which the wind had swept the snow. Its cultivation being abandoned on the prairies, it was thereafter limited to the township of Florence, where it has principally been cultivated ever since, there being but little over one hundred acres employed in mint, outside of St. Joseph county, in the whole state.

During the first year of its production the oil was purchased by the village merchants and exchanged in New York City for merchandise suited to their trade. As the product increased, these merchants acted as agents for eastern dealers, who bought, sold or exported it, shipping it to Europe, where it was principally disposed of in the Liverpool market.

The mint oil being a fancy product, and not a substantial staple commodity of commerce, the surplus, after our own and the European market was supplied, was of little value until there occurred a new demand. As a natural consequence, competition in speculation upon its purchase and sale in the city of New York became hazardous, there being many houses more or less engaged in the business. At one time (about 1844) the house of Patterson, Stone & Co., in that city, adopted the following enterprise, with the view of monopolizing the trade in mint oil:

This house first sent an agent to Europe to determine the amount of the demand in the Liverpool market. This he did, ascertaining it to be about 12,000 pounds per annum. They then sent another agent west, to determine the amount of the product annually. This agent found plantations in Wayne and other counties of Western New York; others still larger in the counties of Ashtabula, Geauga and Cuyahoga, Ohio, and finally those of Florence, in this state. The plantations in New York did not produce enough, those in Ohio too much and those in Florence just about the quantity required to supply the Liverpool market. He consequently entered into contract with the producers in New York and Ohio, whereby he bound them under heavy penalties to plow up their mint fields, destroy the roots, and not plant any more mint or sell or give away any roots, or produce or sell any mint oil for the period of five years. He paid them one dollar and fifty cents per acre as a bonus for so doing. He then contracted with the producers of St. Joseph county to pay them two dollars and fifty cents for their mint oil, delivered at such agencies as he established in the county for that purpose, for a like period of five years, binding them under heavy forfeitures not to sell roots to any one; not to extend their own plantations themselves, and to deliver every ounce

of mint oil produced by them to the agents under the contract. These contracts continued to be observed for about three years by the producers, when, the house having gained the desired end of this monoply, a large fortune, it ceased to enforce the contracts. By this time, also, many of the producers had amassed fortunes from their mint product, retired from the business and seeded down their farms. Other fields had run out and new ones were converted into mint fields; the production of the oil again became general, and has since continued so, but limited mostly to Florence.

No one ought to engage in the work of cultivating medicinal plants without consulting those who can give him some information as to the probable quantities of drugs that may be required. Unfortunately, statistics are not easily procurable, and I have never been able to satisfy myself as to the quantities that are annually used of any one drug, but drug dealers will supply information as to market conditions and probable needs at any one time. I, however, think that the greatest danger does not lie in the over-production. Some mistakes will doubtless be made, but the mistakes of wrong decision in this matter will not equal those of indecision, which is very vital at this time. The assuming of a negative attitude or a "do-nothing position" on this subject means the dwarfing and killing of the whole problem, unless the antagonism may put those who are giving the subject consideration on their mettle. The fact is, however, there are so many practical problems that require attention that we need all the constructive thought possible. The first question that should be answered is, "Why is it necessary to grow medicinal plants?" The principal reason is one which is seldom emphasized or taken into consideration. We ought to grow drug-yielding plants in order that we can obtain drugs of uniform quality. At the present time any lot of drugs may represent the work of a great many unskilled collectors, situated at widely different points and collecting at widely different seasons. The only way that this can be avoided is to establish farms where the drugs can be harvested under competent directions, assaying the material so as to check up its real medicinal value. It is almost self-evident that we never will secure drugs of uniform quality unless they are derived from plants developed under control and which have been grown from seed, the origin and nature of which is known.

A second reason for growing medicinal plants, which is usually given precedence, is that the amount of active principles be increased. If plants are kept under surveillance and the experiments conducted under scientific management, this increase in active principles is sure to follow, for by selection and conservation of the seed, plants particularly rich in active principles will continue to be propagated. Ultimately drug products, like farm products, will represent the sum of experience and include only those desirable varieties of the highest grade.

The third reason that is usually given for taking up the cultivation of medicinal plants is that our drug supplies, and that applies especially to native

drugs, are becoming scarce. In fact, every many of them as ginseng, pink-root, male fern and others are pretty nearly exterminated. For this reason alone it is only a matter of a few years, if drugs are to be used at all, until our supplies must of a necessity come from plants under cultivation. Of course, not all plants used in medicine should be intensively cultivated. Of the 10,000 plants used in medicine in all parts of the world probably not more than 10% are of permanent value.

In order to succeed in drug farming there are two mighty important questions that need to be answered to put this industry on a paying basis. The first of these relates to the growth of seedlings. In Michigan and in most places where experiments have been conducted, it is necessary to germinate the seeds in greenhouses or cold frames and to transplant the seedlings to the field. As most seeds require from four to eight weeks for germination, and an equal time is necessary for them to get fairly well established, it is apparent that by starting them in the greenhouse we save four to five months of time. But this requires a great deal of space and consumes a great deal of fuel, as the preliminary steps are taken in January and continued during the coldest weather. Then, too, considerable labor is required in transplanting these seedlings from the seed pans to the flower pots and from the greenhouse to the cold frame. If they could be sown directly in the open and brought to maturity before the cold weather of autumn, there could be a considerable saving of expense and labor. The experiments conducted here last summer show that many plants can be grown in the open, but the crop will only be from 10% to 20%, compared to that obtained from plants previously started in the greenhouse. Therefore one of the first problems is to obtain seed which will germinate rather quickly and at relatively low temperatures, and which will run through the vegetative period rather quickly.

Then again we need to know more in regard to soil conditions and the use of fertilizers. Some of them increase the growth of the plants, giving vigorous stems but less leaf area and root production. In other words, growth is at the expense of the active principles, and the increase is really a loss rather than a benefit. During the past year we have not utilized any fertilizer, and yet the plants have been excessively high in active principles. There can be no question but the judicious use of fertilizers will help to improve the quality as well as yield of drug. As a general rule, a well-rotted barn yard manure seems to be the best for general applications. Next to this a mixed fertilizer, such as ordinarily used on farms, gives excellent results, provided it is worked well into the furrows. Hand in hand with the subject of fertilizers goes the subject of cultivation. In most cases weeds and other farm plants should be excluded, but there are doubtless many instances, as in the case of woodland plants, which are shade-loving, in which a mixture or society of plants would prove beneficial. This would especially apply to plants like ginseng, golden seal, mandrake, and others of this type. Many of

the experiments which have been made seem to show that continuous sunshine, especially when accompanied with hot and dry weather, is detrimental to the growth of the plants. This, however, has not been my experience at the University of Michigan. Here the natural conditions seem to favor the best production and maximum yields, the plants withstanding even temperatures of 115° F. and prolonged drought.

Probably the most important phase of the economic production of drugs is the question of collecting and preparing them for the market. Nearly every one who has gone into this work has installed some special drying apparatus, usually employing a certain amount of heat. In case of belladonna and digitalis, the leaves are separated from the plant, placed in separate layers on frames and dried, using artificial heat. This again is expensive, requiring considerable labor and drying facilities. If the stalks are strung on wires or spread in drying sheds, and thus protected from rains and dews, there will be a great saving of labor and a much larger crop can be handled. This latter plan was followed at the University of Michigan, and all of the plants thus far examined have shown an activity at least twice that of the official standards prescribed.

The number of medicinal plants which have been cultivated is exceedingly small, and the failure of attempts to cultivate a larger number is rather surprising in the light of the results which have been secured during the past season at the University of Michigan. The reason why so many plants were grown was because it was anticipated that about 90 or 95% of them would succumb in the course of the season. As it was every plant, of which we had seed which would germinate, did well, even in the open.

The following is a list of plants which were grown at the University Botanic Gardens:

No attempt is made to distinguish between the really useful and those which might be considered by some to be unimportant. They all are used to some extent and have a market value.

1. *Althaea officinalis* L. (marsh-mallow). A perennial herb, with rose-colored flowers. It somewhat resembles the hollyhock, the plant flowering from July to September, the seeds following in little capsules or buttons. The whole plant is mucilaginous, but the root is the only part used in medicine in this country. The leaves and flowers are also used in Europe.

2. *Anethum graveolens* L. (garden dill). The plant resembles fennel, but is smaller. All parts are aromatic, the leaves being used chiefly as a flavoring for culinary purposes. The fruit is used to some extent in medicine, and the aromatic water produced therefrom is official in Great Britain, where it is used as a vehicle in medicine, closely resembling caraway water. The aromatic properties are due to an oil which is present from two to four per cent in the fruits.

3. *Anthemis tinctoria* L. (yellow chamomile). It is a low plant resembling the plants commonly known as chamomile, but with large yellow ray flowers. It is occasionally employed in Europe as a tonic and vermifuge. Our great interest is in the fact that it is sometimes used as an adulterant of arnica flowers, and is to be distinguished only by the fact that arnica has a series of bristles at the summit of the achenes.

4. *Arctium Lappa* L. (Burdock). This is a common weed, and while at the present time it is not generally believed to have any medicinal value, the fluid extract is recognized by the National Formulary. The root, as well as the leaves, have been used as an alterative and in chronic skin diseases.

5. *Artemisia Absinthium* L. (worm-wood). No less than thirteen different species of Artemisia are used in medicine. As one would infer from the name worm-wood, this plant is used as an anthelmintic. It is not much used at the present time owing to the fact that there are other drugs, such as thymol, oil of chenopodium, santonin and a few others having the same specific actions. There are, however, a great many valuable anthelmintics which have gone out of fashion because either of the inferiority of the drug on the market, or its not having been carefully investigated, and any one or all of them may come into vogue again. An infusion, as well as the volatile oil, of worm-wood is used in medicine. The oil also enters into the liquor known as absinthe, which, however, is debarred importation in the United States at the present time.

6. *Atropa Belladonna* L. (deadly night-shade). Almost all the parts of this plant, with the exception of the thick, woody main stem, are used in medicine. The roots, leaves and young stems, with their flowers and fruits, are official in all of the pharmacopœias of the world. The plant is a native of Central and Southern Europe, and it is rather strange that it is not naturalized outside of these countries, although it has been reported as growing in Michigan. It grows vigorously under cultivation in England, France and the United States. In countries where it is indigenous the seed can be sown in the open, but in other places it is necessary to start the plants in the greenhouse, the sowing usually being made by the first of February. Experiments, furthermore, conducted in the United States seem to show that the plant will not over-winter, and in order to secure large roots of the second and third year crops, the roots must be dug up before the advent of frost, carefully stored during the winter and transplanted the following spring.

7. *Atropa physalodes* L. (apple of Peru, Peruvian bluebell). This is a large herb with nodding blue flowers, and the specific name is derived from the Greek, meaning bladder-like, alluding to the fruit being enclosed in an inflated calyx.

8. *Aquilegia vulgaris* L. (garden columbine). This plant is a native of Europe, cultivated in our gardens and naturalized especially in some of the northern states. It was at one time used in medicine. The flowers have a

great variety of shades ranging from pink to blue, some even being white. They are also interesting, because the petals are prolonged into large hollow spurs, which are straight, and the flowers of which are scarlet on the outer surface and yellow on the inner.

9. *Borago officinalis* L. (borage, star-flower). This is a European annual with a spreading five-parted blue corolla. The plants abound in mucilage and contain besides considerable potassium nitrate and other salts.

10. *Calendula officinalis* L. (marigold). This is a plant of the cultivated gardens, but should not be confused with the French or African marigold, of which there are some beautiful double varieties, but which are an entirely different plant, being *Tagetes patula* L. and *Tagetes erecta.* L. For a long time a tincture made from the yellow florets was official. It is still retained in the National Formulary and used by the homeopathic physicians, who employ a rather excellent preparation made from the fresh florets.

11. *Cannabis sativa* L. and the *variety indica* Lam. (East Indian hemp, or American hemp). The stems yield on retting a fibre known as hemp; the fruit, or so-called seeds, are used as a food for birds, and the resinous tops are official in very many of the pharmacopœias. For years it was the Cannabis grown in the East Indies that was used in medicine throughout the world. Within the past few years the Indian government has placed a high tax on every pound of the drug that is grown. The result has been that other supplies were sought, and it was found that the plant could be grown in other parts of the world, and today the hemp plant is cultivated in Asia, Africa and the United States. At first the American drug did not seem to be of like quality, but by careful selection and experimentation a drug has been obtainable from plants grown in the United States which is the equal of that formerly imported from India.

12. *Carum Carvi* L. (Caraway, caraway seed). The fruits of this plant are commonly added to cakes and bread to give them an agreeable taste. The fruits are also used in medicine, either in the form of an infusion or an aqueous distillate prepared from them or a volatile oil, which is extracted. The latter contains thymol, which is a specific in the treatment of hookworm. The caraway plant is a biennial. The fruits are obtained, after it has been cut down and allowed to dry, by threshing the plant on a cloth. For some time back the market supplies have been obtained in part from American grown plants, though its fruits are usually somewhat smaller than those imported from Europe.

13. *Chenopodium Ambrosioides* L. var. *anthelminticum* (L.) Gray (American worm seed). About the time that the importations of thymol were considerably lessened it was very fortunately ascertained that oil of chenopodium was equally as efficient as thymol in the treatment of both hookworm and tapeworm. Indeed, at the present time it is considered because of its efficiency, low toxicity and ease of administration, the most valuable of all vermifuge

remedies. There has also been a prevalent notion that the chenopodium plant could only be grown in certain parts of Maryland. It is true that the Maryland oil may be of a higher grade, but the oil distilled from plants grown at Ann Arbor show a remarkably high efficiency, and it is not at all unlikely that when we secure seeds of the best variety and properly understand the distillation, the oil from Michigan will be an important commercial source of the oil. The oil apparently is produced in hairs on the immature seeds, being held within a thin bladdery fruit wall which encases the whole. The worm-seed plant is cut down, dried and the fruits separated by means of threshing.

14. *Coix lacryma-Jobi* L. (Job's tears). This plant belongs to the grasses, and is indigenous to the East Indies and Japan. The so-called seed is really a fruit, being nearly spherical, aboue one-quarter inch in diameter, shining, white and very hard. It is sometimes used in the making of necklaces for teething children, the impression being that they will cut their teeth more easliy. I suppose, however, that the children use it like orris root or other hard substance in rubbing it against the gums, thus facilitating teething.

15. *Conium Maculatum* L. (Poison hemlock). The small fruits of this plant are said to have been used by the Athenians to destroy the life of condemned individuals. An infusion was used to kill Socrates and Phocion. It has been used as a medicine since very ancient times, the fruit and leaves both being used. It is a rather pretty plant, having large decompound leaves and umbels of small white flowers. The fruits are gathered when full grown, but while still green. The leaves should be gathered at the time of the flowering of the plant, quickly dried and carefully preserved.

16. *Datura meteloides*.. Dc. This is a tropical species, having all the appearances and properties of our common Jimson weed. It is, however, a more robust plant, branching profusely and bearing very large white flowers. On account of its high yield of alkaloids it might profitably be hybridized with our native Jimson weed. In fact, there are a great many tropical forms of Daturas which have been successfully cultivated and are used for decorative purposes. They are nearly all rich in alkaloids. Hardly any of these tropical species have become naturalized, as the seeds apparently will not over-winter, but one of them, *Datura Metel*, L. is becoming somewhat frequent in waste ground.

17. *Datura Stramonium* L. and *Datura Tatula* L. (Jamestown or Jimson Weed). These are two rather common and rank weeds. The leaves and flowering branches are official. These plants are good examples of the desirability of cultivating, even such common and widespread plants. The commercial drug varies very greatly in its alkaloidal content, and in cultivating it, it is expected that desirable strains may be obtained of uniformly high activity. It has been found that the application of certain nitrogenous fertilizers will cause a perceptible increase in the amount of active principles. But the results are not yet conclusive, so experiments are being conducted in this

country with the view of increasing the alkaloidal content by selection of seeds.

18. *Digitalis purpurea* L. (Fox glove). This one of the five most important drugs used in medicine, the others being opium, yielding morphine, cinchona, yielding quinine, iodine and mercury and its salts. Under the name of *Digitalis gloxiniaeflora* Carr, there are a number of horticultural varieties of *Digitalis purpurea* cultivated in the gardens. They are all more or less toxic. The form which produces purplish flowers that are more or less spotted is the one used in medicine. It is a biennial plant, producing flowers in the second year. In this country it has escaped to some extent from the garden, and in Oregon and Washington grows wild. Digitalis has been quite extensively cultivated in the United States during the past few years, and it is the work done in this country which has thrown considerable light on the nature of the drug and its constitutents, as well as its physiological action.

19. *Digitalis grandiflora*. Lam. This is a biennial or perennial plant, with ovate lanceolate leaves and large yellowish flowers. The plant, growing in Switzerland, seems to be quite as efficient as the common Foxglove.

20. *Digitalis lanata*. Ehrh. This plant produces oblong or lanceolate leaves and rather small flowers varying from a creamy yellow to a whitish or purplish color.

21. *Digitalis sibirica*. Lindl. This may be only a form of digitalis lanata, as the flowers closely resemble the latter species. Experiments are being conducted with these and several other species of Digitalis, besides purpurea, with the view of determining if one or more of them may not give with greater uniformity the heart-acting principle and possibly enable us to make a more permanent preparation.

22. *Grindelia squarrosa* (Pursh) Dunal. (California gum plant). This plant is found on the prairies and dry banks of the western states. On account of its scarcity it is being cultivated. It is commonly employed in the treatment of bronchial catarrhs. The plant is rather easily grown from seed, and if the cluster of radical leaves prove to be as efficient as the stem leaves and flowers of the second year plant used at the present time ,the drug on the market will be considerably improved.

23. *Helianthus annuus* L. (Sunflower). This plant is very extensively cultivated in China, Europe and in the United States for the fixed oil obtained from the seeds, as much as 275 pounds of oil often being the yield per acre. In Russia the seeds are also eaten, the same as the Americans eat peanuts, and it is not uncommon to find the vender on the sidewalk with his tray of sunflower seeds. The pith is valuable as a source of cellulose, and the leaves are used by the people of the Caucasus in the treatment of malaria.

24. *Hyoscyamus niger* L. (Henbane). This species produces two forms, the one annual and the other biennial; in fact, may be said to possess an alternating annual or biennial habit. Apart from its medicinal interest, this would

be one of the most interesting plants for the study of the origin and nature of the biennial habit of many plants. For a time considerable difficulty was experienced in growing henbane in this country, but at present it is recognized that if the plants are subjected to severe cold, as 20° F., they will germinate readily. Indeed, in certain parts of the West, as in Oregon, the plant has become well established. It is also reported to be well established in Mackinac Island, in the Straits of Mackinac, between the two peninsulas of Michigan and on the adjacent mainland on either side.

25. *Hyoscyamus niger L. var. pallidus.* Wald. and Kit. This is a plant resembling the annual henbane, but producing yellow flowers.

26. *Inula Helenium* L. (Elecampane). This is a perennial herb naturalized in Europe and growing in many places in the northern United States, sometimes occurring as far west as Missouri. It has considerable interest in medicine and is recognized in the National Formulary.

27. *Levisticum officinale* (L.) Koch. (Lovage). This is a branching perennial herb, producing small greenish-yellow flowers, which are followed by the strongly aromatic fruits. The parts used in medicine are the roots and fruits. The plant contains an interesting coloring principle, which may be used to identify limestone water. If the water is pure or neutral, the principle gives it a crimson color, but if it is alkaline a blue color appears.

28. *Martynia Louisiana Mill.* (Unicorn plant). This is a low plant, with heart-shaped leaves and beautiful white or purplish spotted flowers. The fruit is terminated by a two-horned beak, causing some species growing in Mexico to be known by the name of Devil's claw, in allusion to the clinging hooked fruits.

29. *Matricaria Chamomilla* L. (German Chamomile). There are two genera of the compositae which furnish plants commonly known as chamomile. One of these is the genus *Anthemis*, which furnishes the garden or English chamomile. There is another plant of this genus, *Anthemis Cotula*, L. which is very common and known as May weed, or Dog fennel. This latter plant looks like a daisy, and flowers throughout the Summer. A plant resembling this is the *Matricaria Chamomilla*, but this is very sparingly naturalized. The German chamomile, which is official, comes to us from Germany and is usually collected from wild plants. It is well worth cultivation, as it has been commanding a price of 50 cents a pound. The flowers only are used in medicine, although all parts of the plant are valuable. It is chiefly used as a mild tonic, but is also useful as an anthelmintic.

30. *Nepeta Cataria* L. (Catnip). This European plant is not infrequently found as a common weed near dwellings, having been introduced through its cultivation. It is used to some extent in medicine, and is still recognized in the National Formulary. The name Catnip is given to it because of the fondness which cats show for it either in the fresh or dried condition. The leaves and flowering tops are used in medicine.

31. *Nicotiana Tabacum* L. (Tobacco). Notwithstanding the fact that not less than 1,000,000 tons of tobacco are used annually for smoking and chewing purposes, a small quantity is used in medicine. In fact, the oil of tobacco was at one time official, and was extensively used during the early and middle part of the last century. There are a number of varieties of *Nicotinana Tabacum which are cultivated;* we have had the Pennsylvania and the Havana varieties in cultivation. These two forms resemble each other, but the Havana form has more ovate leaves and dark pink flowers. The value of tobacco depends on it being properly cured and prepared for market.

32. *Ocimum Basilicum* L. (Sweet Basil). An annual herb commonly cultivated as a seasoning, but having also the medicinal properties of other mints. It yields an interesting oil, which, upon investigation, may support the view that it has some value in genito-urinary diseases.

33. *Origanum majorana* L. (Sweet Marjoram). Cultivated as a garden herb in Europe, as well as the United States. It is used more as a condiment than as a medicine. It is extensively used, and during recent years the imported article has been adulterated with the leaves of the dyer's or poison sumach (*Coriaria myrtifolia* L.) Formerly it was used like saffron and other drugs in domestic practice, especially in the form of a tea.

34. *Papaver somniforum* L. (Opium poppy). This species and its variety *album* D. C., furnish the opium of commerce. The plant is readily grown and very excellent fruits or capsules can be obtained, but considerable work is necessary before we will probably make its cultivation a commercial success. Our work with it this year has been somewhat disappointing, but this is largely due to the fact that we were unable to handle the capsules while they were in the green condition. It is at this time when they contain the largest amount of morphine. In Oriental countries, where the poppy plant is grown, it is usual to select those fruits which are just turning a light brown, making incisions which causes the opium to exude. The incisions are made in the evening, and before sunrise the next morning the juice is collected in jars, the whole being kept until the harvest is finished. In addition to the opium which the opium poppy furnishes, it yields an interesting seed (Maw seed), which is rich in a fixed oil. The oil is used as a substitute for olive oil, both for culinary and industrial purposes.

35. *Pentstemon laevigatus Ait. var. Digitalis.*. (Sweet) Gray. A perennial herb, with opposite ovate-oblong or lanceolate leaves and spikes of light purplish flowers. The plant is indigenous to some of the central states, and its study may have some scientific interest. At any rate it has been grown successfully in Ann Arbor.

36. *Phytolacca decandra* L. (Poke root). Both the root and berries of this common but rather striking plant have received official recognition. Preparations are used in the treatment of rheumatism, those of the root being especially esteemed. The berries are collected when ripe; the root

should be dug after frost. There are some people who gather the young shoots in the early Spring and use them in the same manner as asparagus. It is also of interest that the ashes of this plant contain a large quantity of potassium.

37. *Polypodium vulgare* L. (Licorice fern). This fern resembles the common polypody and is a native of Washington. It contains a substance which resembles the glycyrrhizin, the sweet principle occurring in licorice root.

38. *Pycnanthemum flexulosum* (Walt.) B. S. P. (Mountain mint). Perennial herb, having a pungent mint-like flavor. The plant is nearly smooth, the leaves linear or lanceolate and somewhat downy. The flowers are slightly purplish and the floral leaves somewhat whitened. The plant has a local use in medicine and contains an interesting volatile oil.

39. *Rheum officinale* Baill, and *Rheum palamtum* L. (Rhubarb). This plant resembles the common garden rhubarb, but has a thick fleshy rhizome, which is the part used in medicine. These plants seem to do well in this climate. While both of these species of Rheum seem to be the plants from which the Chinese obtain their medicinal rhubarb, and while these plants have been extensively cultivated since they were first grown by Soubeiran in 1867, yet none of this cultivated product seems to be equal to that of the Chinese drug. In all probability greater care is needed in cultivating the plant and in pruning the overground shoots.

40. *Salvia officinalis* L. (Sage.) The common garden sage is rather well known and has been extensively cultivated. It flowers in June, and it is at this time that the plant should be cut down and carefully dried. The leaves and tops are largely used as a condiment, but they are also used in medicine, the plant having been very highly esteemed since ancient times. Other species of Salvia are recognized in some of the foreign pharmacopœias. The seeds of some of these other species are used for food and are therefore of some interest.

41. *Satureja hortensis* L. (Summer Savory). A perennial herb, native of Europe and cultivated for culinary uses. It has a thyme-like odor and flavor. The volatile oil is of some interest and should be investigated.

42. *Silybum Marianum* Gaertn. (Milk Thistle). There are a great many plants of the compositae that produce prickly leaves and the receptacles are more or less spinose. Some of these are used in medicine as, the "Milk thistle" and the "Blessed thistle," both of which are used somewhat extensively in European countries. The milk thistle has large mottled leaves, which are very prickly; it produces large heads of purple flowers. In growing this plant great care should be exercised that the seeds are not disseminated so as to make it a noxious weed; to prevent this, the flowers should be gathered as soon as they appear.

43. *Solanum Dulcamara* L. (Bittersweet). The stems of this plant were formerly official and are included in the National Formulary. It is a very common climbing or twining plant in and about Ann Arbor, and is distinguished by its purplish or blue flowers, which are replaced in the fall by small red ovoid berries.

44. *Solanum Douglasii* Dunal. A plant somewhat resembling in its general habit the common night-shade (Solanum nigrum). It is a native of California, and the interest in the plant lies in the possibility of its being a source of solanine, an important gluco-alkaloid, which is used in the treatment of nervous diseases.

45. *Solanum nigrum* L. (Common Night-shade). An annual plant growing in many parts of the United States. There are varying reports as to whether any parts of this plant are really poisonous. It should be investigated. It has ordinarily been difficult to secure the plant in any quantity, and it is rather gratifying that it can be grown so easily and obtained in any quantity desired.

46. *Symphytum officinale* L. (Comfrey). A European plant, which is cultivated to some extent, but which has also escaped from the gardens. The root is the part highly esteemed and used in the treatment of pulmonary disease in domestic practice in Europe. It is rather a coarse herb, having large ovate or ovate-lanceolate leaves, the petioles being attached to the stem and the flowers varying from yellowish to pink or blue.

47. *Tanacetum vulgare* L. (Tansy). This common garden plant was at one time official in the United States Pharmacopœia. It has been used in the treatment of a great variety of diseases.

48. *Thymus vulgaris* L. (Common or garden thyme). A small evergreen shrub, indigenous to Spain and Italy, and extensively cultivated in Europe and the United States. Our supply of this drug came to us formerly from Germany. It is now somewhat extensively cultivated in New York state, and its cultivation should be extended. It yields thymol, a principle which is largely used in the treatment of hookworm. It is also a valuable disinfectant, being used like carbolic acid. It has the advantage of possessing a more agreeable odor.

49. *Verbascum nigrum* L. and *Verbascum phlomoides* L. These two plants resemble the common mullein. They are to some extent used in medicine, but one of the chief objects of cultivating them has been to study the plants at close range with a view of detecting their presence in Digitalis, the foreign drug sometimes being admixed with these leaves.

50. *Valeriana officinalis* L. (Valerian or garden heliotrope.) A rather pretty herbacous plant with pinnately compound leaves and large cymes of white or rose colored flowers. The rhizomes and roots are used in medicine. The plant has been cultivated locally in the United States and should be of

very great interest to growers of medicinal plants as our supplies of the official drug have been very scarce. At the present time we are using a Japanese Valerian and it is very doubtful if it has the same properties as the European plant which is also the species cultivated in the United States.

Sinapis alba L. (Yellow mustard) *and Sinapis nigra* L. (Brown mustard). The mustard plants are extensively cultivated in England, Holland, Germany and the United States. California furnishes considerable of the yellow mustard and North Dakota of the brown mustard. These plants are easily grown, the seeds being planted in the open in early June, the plants flowering and fruiting in August. The tops are cut down and the seeds obtained by threshing. At the University of Michigan, several varieties were grown including Chinese yellow, Indian Tori, California brown mustard and rape seed.

Iris germanica L. (Orris root). This plant is a native of Italy and is cultivated in a number of countries bordering the Mediterranean. The commerce supplies are obtained chiefly from the neighborhood of Florence. It is chiefly used in the making of sachets and used in the perfuming of toilet preparations.

For some years past the botanic gardens of the University of Michigan have contained small plots of several medicinal plants. The latter have over-wintered and done remarkably well. These plants are of considerable interest and should be grown on a large scale. Among these is the ordinary Celandine which contains a principle which in its physiological action is a good deal like morphine but is better tolerated than that drug by certain classes of people and especially children. Lavender is an important perfume yielding plant and the flowers produced at Ann Arbor are among the most aromatic I have seen. The species of Chrysanthemum which furnish Insect Powder thrive very well in this locality also.

In addition to the above mentioned plants, which have been grown during the past summer in Ann Arbor, the writer has had under cultivation either in the greenhouse or out in the open a large number of other plants, most of which can be successfully grown. They are:

Aconitum Napellus L.
Aloe vera L.
Aloe ferox Mill.
Anemone Pulsatilla L.
Aristolochia Serpentaria L.
Asclepias tuberosum L.
Aspidium marginale (L.) Sw.
Brauneria angustifolia (DC.) Heller.
Brauneria pallida (Nutt.) Britton.
Cereus grandiflorus L.
Chamaelirium luteum (L.) Gray.
Convallaria majalis L.
Cypripedium parviflorum Salisb.
Cypripedium parviflorum Salisb. var. *pubescens* (Willd.) Knight.
Daphne Mezerum L.
Eucalyptus Globulus Labill.
Gardenia jasminoides Ellis.
Gelsemium sempervirens (L.) Ait. f.
Geranium maculatum L.
Glycyrrhiza glabra L.

Helleborus niger L.
Hydrastis canadensis L.
Iris versicolor L.
Jasminum officinale L.
Laurus nobilis L.
Magnolia fuscata Andr.
Melia Azedarach L.
Myrtus communis L.
Olea europaea L.
Panax quinquefolia L.
Passiflora incarnata L.
Phlox ovata L.
Phlox paniculata L.
Podophyllum peltatum L.
Polygala Senega L.
Prunus Laurocerasus L.
Punica Granatum L.
Rosmarinus officinalis L.
Sanguinaria canadensis L.
Viburnum Opulus L.
Viburnum prunifolium L.

PRACTICAL CULTIVATION.

It is necessary to study the best ways of propagating the plant one wishes to grow. Sometimes this is by means of seeds, as in the case of belladonna and digitalis; at other times it is by propagation of rhizomes, as hydrastis and glycyrrhiza; or again it is by rootstocks or prostrate stems as in the mints. Sometimes both seeds and cuttings may be used as in the case of hydrastis.

Plants grown from seeds. Most plants can be grown from seed, Mitlacher has given the results obtained with rhubarb, valerian, poppy, matricaria, lavandula, hyoscyamus, gentian, pyrethrum, althaea, aconite, etc. When plants are grown from seeds, especially if in a temperate climate where the growing season is rather short, it is necessary to begin the germination of the seed early in the spring. This must be done then in the house or under conditions where there is some protection. These seeds may be sown either in small boxes or in seed pans, i. e., shallow, square, flower pots, in which the soil is quite sandy or made up largely of broken granitic rock. The soil must be clean and free from organic matter which is likely to mould. The seeds should not be planted too deep and should be covered with glass so as to condense or hold moisture. Of course, where there is the necessary attention in keeping the earth moist, this glass can be dispensed with. The time required in germination will vary considerably. Many seeds will germinate well within two weeks; usually about four or five weeks is necessary.

Occasionally some seeds, as the roses, may require a year or two before they germinate. The present tendency is to shorten the period of germination in several ways. The simplest, possibly, is to place the seeds in water for 24 hours. When the seed coat is somewhat resistent, germination may be hastened by pouring boiling water upon them. Again, some special treatment may be given them as the use of dilute or even concentrated mineral acids In the cultivation of maté for many years it was found that the seeds would not germinate unless they had previously passed through the alimentary tract of certain birds. Later it was found that the same end could be obtained by placing the seeds for a short time in solutions of hydrochloric acid. F. A.

Miller reports that he has obtained good results in the case of belladonna by placing the seeds for thirty or forty seconds in concentrated sulphuric acid. The germination of seeds may also be hastened by certain mechanical means. This is used when the seed coat is particularly thick and not easily penetrated by the moisture, when, if they are large, they are filed in one or two places. If they are small they may be shaken with sharp angular sand until the exterior is somewhat roughened.

After the seedlings have a few leaves upon them they are then set out in suitable boxes known as "flats." These are about three inches deep and about two feet square and the soil used should be of a sandy character, containing a certain amount of nutriment, however. The plants must be watched at this point to see that there is no damping off and loss by reason of the attacks of micro-organisms in the soil.

Should there be a damping off and loss of seedlings, then one must study methods for overcoming this. Recently the Department of Agriculture has utilized dilute sulphuric acid for this purpose which I have shown is the active principle produced whenever sulphur is used in the greenhouse. It is one of the most effective agents for the destruction of insect pests as well as the blights due to fungi and other micro-organisms.

The seedlings are allowed to grow in the "flats" until they have developed a good root system and have three or four leaves. Before placing them directly in the soil out of doors they are acclimatized or hardened by placing them in cold frames. This transferral should be done not later than the early part of May. The structure and use of the cold frame is perfectly familiar to the practical gardener. Information regarding the construction of this accessory to the garden can be had of any of the seedsmen. In fact, in many instances, they publish small booklets entitled "Vegetables under Glass" giving information on the tilling of soil during the entire year, and these booklets can usually be had at a very moderate figure. Sometimes the plants are removed from the flats and placed directly in the soil in cold frames. This may give a temporary setback to the plants as the roots are more or less disturbed by the operation but if one wishes to continue the experiment in the cold frames, later removing the sash, considerable time will be saved.

If the plants are to be transplanted out of doors it is very desirable that this should be done as soon as possible after the last days of frost are likely to occur in the given locality. The plants are arranged in rows and set sufficiently far apart so the maximum crop per acre can be obtained. Usually they are so arranged that weeds may be pulled out and the ground worked over.

The above outline may be used for the propagation of most plants by seedlings, but they must be carefully cared for if one wishes to get maximum results. Some plants are rather easily grown if care is taken with their culture, as digitalis and belladonna. Other plants like hyoscyamus, are cultivated with some difficulty, and very few persons are uniformly successful in growing

aconite. Several good practical papers have been published on the cultivation of digitalis, namely, one by Newcomb and another by Borneman. Some facts regarding the growing of Hydrastis from seed are given in a bulletin of the Bureau of Plant Industry, U. S. Department of Agriculture, by Alice Henkel and G. Fred Henkel and G. Fred Klugh. The subject of growing ginseng from seed is also considered in a bulletin of the Division of Botany, U. S. Department of Agriculture, by George V. Nash. At the present time there is considerable interest in the growing of *Eucalyptus globulus* and other species of Eucalyptus, the seeds of which can be obtained from J. M. Thorburn and Company, New York City. A very valuable monograph on "The Eucalyptus Cultivated in the United States" was prepared by A. J. McClatchie, and published as Bulletin No. 35 of the Bureau of Forestry, U. S. Department of Agriculture. In addition to these special plants which have been mentioned there are a large number of plants yielding medicinal products which are grown from seeds and require no more care than the usual garden plants. Among these are *Calendula*, *Chrysanthemum roseum*, *Echinacea*, and a number of plants grouped under sweet, pot, and medicinal herbs.

Propagation by Cuttings. This is a common method of propagating plants. A cutting is a severed portion of a stem having one or more nodes or buds. They are derived from overground shoots, as in the carnation, rose, geranium, and coleus, or where the plant produces rootstocks or rhizomes, they are made from these rather than from the overground shoots. In propagating plants from rhizomes the latter are cut into pieces, each of which has one or two buds, and these pieces are planted. The propagation by means of cuttings or rootstocks is extensively carried on in the cultivation of peppermint. A. M. Todd, who has been growing peppermint on a very extensive scale, has given in some detail the method of propagating this plant in an article published in the Proceedings of the A. Ph. A. for 1903, P. 277. A later article on the cultivation of peppermint in the United States is one prepared by Miss Henkel and published as Bulletin No. 90, Bureau of Plant Industry, U. S. Department of Agriculture. Hydrastis is another drug, the plant of which is commanding considerable interest and is being propagated by means of rhizomes. There are three good articles which treat of the practical cultivation of Hydrastis, namely: one by John Uri Lloyd in Proceedings of the A. Ph. A. 1905, p. 307; another by Alice Henkel and G. Fred Klugh, in Circular No. 6, Bureau of Plant Industry, U. S. Department of Agriculture; and a third by J. C. Baldwin in *The American Journal of Pharmacy*, April, 1913.

In the case of both ginseng and Hydrastis one-year-old plants are frequently supplied by growers and while taking everything into consideration this is not desirable, yet there may be conditions where, for experimental purposes, they may be used. It should be emphasized that it is not merely a matter of getting rhizomes or young plants but a very careful study should be made of the soil and light conditions which favor the maximum returns from

the crop. The use of manure for increasing the yield of both crop as well as constituents should proceed with a good deal of caution until we know more about the subject.

HARVESTING THE CROPS.

As drugs represent the different parts of the plant they are harvested in different ways and sometimes more than one crop may be obtained in the course of the growing season. There are certain general rules however which might be followed for each class of drugs, classifying them according to the parts of the plant which are used.

1. *Seeds.* Sometimes the principal object is the seed, as in mustard, which by the way can be sown in the open thus yielding a crop in 8 or 10 weeks. When most of the fruits are mature the plants are cut down by means of a scythe, collected, and carried to the drying shed or barn, where they are spread out and allowed to dry. The seed is threshed out and the chaff separated by winnowing. Seeds are collected when fully ripe.

2. *Fruits.* Fruits are usually collected for pharmaceutical purposes when full grown but unripe, i. e., while green and of maximum size. At this stage the active principles are at the maximum. The fruits are collected by hand., those being selected which are at the right stage of maturity, leaving the plant undisturbed. At times it may not pay to make this selection and the main stalk, with the fruiting branches can be cut down with a scythe and the fruit stripped off at the convenience of the worker. This is rather important to remember, as it may save undue exposure to the hot sun and enable the farmer to collect the drug during the cooler part of the day, preparing it afterward under more favorable conditions. This procedure was followed with conium. In the case of this plant the leaves are also used in medicine so it is possible to cut down the entire plant, separating the leaves as well as the fruits and thus securing a double crop. It is possible to secure about 500 pounds of leaves and 100 pounds of fruits per acre.

With the opium poppy it is customary to scratch the surface of the green capsule, causing a light yellowish brown milky juice to exude. This juice when scraped off constitutes the opium of commerce. It was not possible in the experiments this past summer to carry on this operation and so the capsules were cut off and allowed to dry. They should yield from 0.2 to 0.3 per cent of morphine. We do not know as yet what the alkaloidal content of the capsules raised in Michigan will be, but we are determining this at the present time. In addition however to the morphine content of the capsules considerable interest attaches to the seeds contained in them. These seeds commonly known as maw seeds are very rich in a fixed oil. This is without narcotic properties, of a straw yellow color, pleasant almond taste and an appearance resembling olive oil. The seed contains from 50% to 60% of this oil which may be obtained by expression. It is also used in the manu-

facture of paints and soap. Each capsule will contain 3 grams of seed. The yield per acre is approximately 30 pounds of capsules, and 50 pounds of seeds.

Chenopodium or American wormseed produces long spikes of very small fruits. It is not known at just what stage they contain the maximum amount of volatile oil. The plant is several feet in height and develops a very brittle stem. The whole plant is cut down by means of a hatchet and brought to the drying shed where it is spread out to dry, the fruits being separated from the plant. It is quite likely that the leaves and stems also contain considerable volatile oil. It would no doubt be desirable to distill the oil from the green plant, thus saving a great deal of labor in the handling of the crop. The still could be run continuously and require very little attention, so that part of the time could be used in the preparation of the herb for the distillation. About 10,000 plants could be obtained per acre and this would yield about 100 pounds of volatile oil.

3. *Flowers.* Flowers should be gathered either in the bud condition or when they are about to open and are at their best. At this stage they contain the largest quantity of desirable principles. In some cases, as with German chamomile, what is commonly known as the flower but really flowercluster, is collected in its entirely. The simplest way that I have found is to run the hand upward from below through the flowering clusters, thus collecting the stalks which come through the fingers. In this way one can gather five or six or more flowers at a time. The flowers are dried by spreading them out on paper. Chamomile continues to flower from about the middle of July to the first of September. The yield of chamomile flowers would be somewhere between 500 to 1,000 pounds per acre. At the present time this drug is commanding a price of about 50c per pound, so that the returns are very excellent.

Marigold furnishes an important medicine, the strap-shaped yellow florets being separated from the head of flowers. This involves more labor than in the handling of chamomile, but nevertheless does not require skilled labor. The method of separation can be very easily learned, and performed even by children. Marigold flowers develop from the latter part of June until on up to frost. One can collect a large number of flowers throughout the season, and the yield will be from 100 to 200 pounds of drug material.

4. *Leaves and Herbs.* The leaves and flowering and fruiting tops of a great many herbaceous plants are used in medicine. The harvesting of these is rather simple, but considerable space is required for drying them. The shoots can be cut off by means of a scythe and spread out either on the floor or in suitable trays, or hung up on wire to dry. This manner of collecting would apply to belladonna, henbane, Indian hemp, sage, grindelia, catnip, sweet marjoram, thyme, tansy, etc. Nearly all of these plants would yield anywhere from 500 to 1,000 pounds per acre.

One should exercise a good deal of care in harvesting and drying these plants, yet my experience shows that one does not need to go to the extremes

as stated by some who have written on this subject. For instance, it is ordinarily stated that the individual leaves of digitalis should be carefully separated, the stalks and midrib carefully removed, and the leaves spread out on trays and carefully and quickly dried, using artificial heat. The drug which I collected ran unusually high in active principles and was dried with the minimum attention and care because of the difficulties in securing labor. The cluster of root leaves with a portion of the underground root and stem was cut down with a hatchet or spade. In one case the whole cluster of leaves were strung on wires and allowed to dry. In another case the leaves were torn apart and scattered over the floor. The drying in every instance was very slow and I rather anticipated disappointing results. The assays made by Dr. Edmonds of the University of Michigan, showed the yields to run about three times as high as the official standard.

Belladonna is of especial interest because every part of the plant with the exception of the basal portion of the main stem is recognized by the pharmacoepia. Of course one cannot get the largest yield of roots if one is cutting down the tops right along with the expectation of getting a banner crop of leaves and tops. From plants which are set out in early June, one can get from two to four crops of the leaves and shoots per season, as this plant will continue flowering until very cold weather comes. The roots of the plants which have been pruned in this way are not so large. If one wishes to get large roots the plant should be allowed to grow during the entire season. The tops then can be cut down or the entire plant with roots and stem can be removed from the soil, the stem portion being separated by means of a hatchet. Roots, however, which are two or three years old, are preferred, so that the roots of the plants which one wishes to allow to overwinter the stems can be cut down some time in September, depending on the weather. That is, if the plants continue to grow and frosts do not come the entire overground portion can be cut down and will give one from two to four hundred pounds of herb. We secured per acre nearly 1,000 pounds of leaves and tops and 350 pounds of roots.

5. *Roots.* When roots are used in medicine the plants are allowed to grow for at least 2 or 3 years. At this time they contain the largest proportion of bark tissues in which the medicinal constituents reside. These constituents vary during different periods of the year and particularly during the growing period of the plant. As a rule the poisonous principles preponderate when the vegetative processes are about to stop as in the Fall of the year. A similar condition seems to prevail in the Spring just before the plant begins to produce new shoots. When plants are under cultivation it is a comparatively easy matter to locate last year's plants and to spade them out just as soon as frost is out of the ground. Of course there is a possibility of loss from freezing if plants are allowed to overwinter, but I am inclined to think that the medicinal activity is improved by overwintering, as accompanying the

medicinal constituents there are usually a number of bitter and even acrid substances which are destroyed by the cold of winter. Among the root-yielding drug plants which we have grown at the University of Michigan are belladonna, marshmallow, poke and inula. The yield of each of these from first year plants would be from 500 pounds to 1,000 pounds.

CURING AND FERMENTATION.

Recent investigation of drug constituents seems to show that the quality can be improved by subjecting them to a sweating or curing process. During this operation certain aromas are developed which enhance their value. This is probably best seen in the curing of tobacco where we begin with a leaf that has neither flavor nor aroma but develops a final product that is fit for the enjoyment of the gods. The value of tobacco depends not so much upon the nicotine content as upon the generation of minute quantities of those constituents which give it its particular flavor and aroma. Of course, in the curing of tobacco there are other qualities which must be developed as that of burning or proper combustion.

Apart from climate and soil there are three prime factors which underly the curing of tobacco, namely, heat, moisture and light. Of course there must be proper ventilation and the time element is an important one. It was with the view of studying these fundamental changes that a considerable number of Havana and Pennsylvania tobacco plants were grown at the University Gardens. The results thus far would seem to indicate that tobacco may be made a valuable product in this vicinity and acre yielding at least 40,000 large leaves.

In quite a number of medicinal plants the poisonous constituent is generated by what is known as a mother substance. The latter is broken down in the process of curing, thus generating a number of important principles. This is well illustrated in the curing of vanilla, where the odorous principle known as vanillin is produced during the fermentation. A number of years ago, Mr. Knox, a student in the College of Pharmacy, University of Michigan, showed that in cola the caffiene was produced in a similar way from a mother substance. It is quite likely that in belladonna, digitalis and a number of other plants a slow drying will enhance the value of the leaves. In other words, if the leaves are first allowed to wilt, preferably in the shade and to some extent allowed to sweat, care being taken that the temperature does not get too high, it is likely that superior drugs will be produced. This is one of the most valuable results of our work at the garden during the past summer.

One of the most interesting plants that we had under cultivation during the past summer was rhubarb. The plant yielding this drug resembles the garden rhubarb but produces large fleshy rhizomes which it seems quite likely will overwinter. I had similar plants growing in large packing boxes placed on a roof when I was conducting experiments in Philadelphia. These lived

from year to year. The roots may not be as large or of as fine quality as those produced in China, but the obtaining of a finer drug material is doubtlessly merely a matter of a better understanding of the cultivation of the plant. The use of fertilizers and a certain amount of protection may be required.

BIENNIAL PLANTS.

There are quite a number of medicinal plants that do not yield drugs until the second year, such as some forms of henbane, caraway, etc. Such plants will need some sort of covering or protection so that the loss from freezing would be reduced to the minimum. Again it may be that some of these plants will be found to be valuable in the first year. The studies made in the United States have proven this to be true of digitalis and in fact, the digitalis leaves of the first year's plants grown at the University of Michigan were three times as strong as that of the official article. This was not true however of henbane, but this is in part due to the fact that the leaves of henbane were badly attacked by the potato beetle, which consumed the fleshy portion between the veins in which the greater part of the active principle resides.

There is another possibility in the case of plants like caraway which do not ordinarily set fruit or seed until the second year. It is possible by starting the plants early enough in the greenhouse and planting them outdoors very early in the Spring to crowd two seasons into one. We did not succeed in doing this with caraway this year, but quite a number of biennial plants bore fruits in the first summer here. This offers very great possibilities in the matter of preserving the fruits of this type of plant and cultivating it to better advantage.

PLANT SELECTION AND BREEDING.

It is well known to nearly everyone how our agricultural crops have been improved by selecting and breeding. Owing to the minor importance of medicinal plants as compared to farm products not much has been done in scientific selection. More attention has been given until now on the possibilities of the use of chemical fertilizers. A priori we can expect the same results in the study of medicinal plants as we have seen with other plants which have been studied scientifically. The experiments made with cinchona in Java will be paralleled with other plants. Here trees running low in alkaloid have been by selection and hybridization made to yield as high as 15% of alkaloid. Furthermore, it has been possible to study them with the view of increasing the most desirable of these alkaloids, quinine. It will be found that one can accomplish almost anything reasonable if he will but start the experiment and continue until he achieves his result. At this point it also should be stated that climate and soil may have some influence, but from our experiments this summer we must either conclude that these factors are

not so important or that the natural conditions in Michigan are very promising.

In the case of stramonium and also belladonna there have been some scientific experiments made which show that of these plants we have several varieties. Of belladonna there is not only the one form bearing purple flowers, but there is another which yields yellow flowers. The relative alkaloidal value of these two plants has never been established. The same is true of stramonium, of which we have not only the common form producing spinose capsules, but another form in which the capsule is perfectly smooth. Of the comparative alkaloidal contents of these two varieties little is known.

FUTURE DEVELOPMENTS.

There is a good deal more to the farming of drug plants than the mere harvesting and disposing of the crop. If the farmer understands the science of pharmacy and is intimately acquainted with the products that his drug crops yield, and their economic uses, he will enjoy many advantages and obtain not only competence but an independence that will make the work far more attractive than mere farming. Probably in no position which one can select are there the opportunities and possibilities for the man of ambition and initiative. Very few plants are used at the present time in the crude form. They are mostly made up into tinctures or fluid extracts and in many instances the active principles are separated as the essential oils. Anyone who takes up drug farming will sooner or later desire to engage in some form of manufacturing. This is not only desirable from the point of view of the cultivator of medicinal plants, but also of benefit to the consumer. If, for instance, one is growing plants yielding volatile oils it follows quite naturally for him to install stills for obtaining the oil and if it is of a high grade it follows quite naturally that he would like to put it up in special containers with his name on the label. High grade finished products always command a good price and there is a great deal of satisfaction to the man who can produce them in having his products so recognized.

1. Essential oil industry. As has already been stated, Michigan today is one of the great centers in the production of the volatile oils of peppermint and spearmint. There are some indications that some of the other plants yielding essential oils could be successfully grown here. The lavender plants which have been grown at the University Gardens are among the finest that I have ever seen. We hope within the next year to carry on experiments with a view to determining the profits that can be derived from a lavender perfume farm.

At the present time there are large quantities of several essential oils which are distilled from our native plants. Among these are sassafras, wintergreen, sweet birch, cedar, wild ginger, and sweet golden rod. All of these oils are largely used and attention to anyone of them would furnish a very

lucrative field. Michigan is an ideal place for the distillation of the oil of wintergreen. In fact, the genuine oil is hardly to be found on the market. Some firms being even unwilling to list it in their price lists because of the difficulty of obtaining the genuine oil. There is then a positive need for the development of this industry. Not that the synthetic oil cannot be used for flavoring and other purposes just as well, but there always will be a demand for the natural oil in medicine. The distillation of these oils is comparatively simple. I, myself, in the laboratory have distilled the oil from a cartload of leaves of wintergreen, obtaining 100 ounces per 1,000 pounds of leaves. In addition to the plants above mentioned we have been growing thyme and orris root. The government issued 20 years ago a Bulletin on "Can Perfumery Farming Succeed in the United States?" This was printed in the year book of the Department of Agriculture for 1898.

2. Alkaloids and proximate principles. It would be a great boom to our chemical industries if many of the chemicals now used abroad were manufactured here. During the past few years some of the active principles have been extracted from American Drugs. One American firm is now producing large quantities of atropine. Comparatively large quantities of the active principles of belladonna, digitalis, Hydrastis, etc., are used in medicine.

The growth of the camphor industry in the Southern United States is but an example of what can be accomplished in our country. There was hardly an incentive to develop this industry, as almost every precedent pointed to the fact that it would be almost impossible to manufacture camphor at a price to compete with that produced on the Island of Formosa. Yet the statistics are showing that even this can be produced in Florida at a profit.

3. Specialties. Some plants are used in some special form and it would be well for the grower to be conversant with the uses to which the crude drug is put. Insect powder for instance is prepared by powdering the dried, unopened flowers or flower buds of two distinct species of chrysanthemum. One can readily see what a very great advantage it would be to not only grow the plants yielding insect powder but to grind them and put up the powder for the use of the trade. This would save transportation in the bulk of the crude drug and the labor involved in powdering would be well repaid. At the present time much of our insect powder comes from Japan and retails for about 80c a pound. The yield of this powder per acre should be about a thousand pounds. Of course this would involve a great deal of labor in picking the flowers at the right stage of development and they would have to be very quickly and carefully dried so that the active principles would be retainedd.

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FARMS VS. FORESTS.

P. S. LOVEJOY.

One-third of Michigan is today bankrupt. Over ten million of the State's thirty-six million acres are laying as waste and idle, desolate and non-productive, as ever the Germans left Picardy. Within a few years the wasted lands of France will be salvaged and will be again be put to work. For long decades yet to come, Michigan will have her millions of acres of non-productive lands.

It is high time that this situation were considered frankly, for its public consideration has usually lacked candor, and, too often, even a decent measure of common truthfulness. Michigan has a problem of physical reconstruction quite comparable with that of France.

Michigan is not alone in this condition. There are today 228,509,000 acres of logged-off, cut-over, fire-ravaged acres of slash lands in the United States. Georgia has twenty million acres, and Alabama, Arkansas, Florida, Louisiana, Michigan, Minnesota, Mississippi, North Carolina, Texas and Wisconsin have each more than ten million acres.[1]

The aggregate of the cut-over lands of the United States represents an area ten times that of of Iowa.

This is no new discovery and no new problem, but constantly it becomes more difficult, more urgent and more specific. Ten times the area of Iowa within the humid part of the United States is cut-over land and the cut-over area is growing at a rate of around 20,000 acres every twenty-four hours![2]

The Ohio valley was originally an almost solid hardwood forest. As the country was settled the forests were destroyed, and in their place, developed fertile farms. On the average, fertile farms developed, but, very often, in spite of the settler's labors or because of them, no farm developed because the land eroded, or because the farm could not support a family.[3]

In any case, the precedent for farm following forest was well established until it became almost an axiom, usually a fixed assumption, often an obsession. Today it is almost universally taken for granted that the logged-off lands will be used for agriculture—that they *must* be used for agriculture—that anything which tends to hasten the process of gettin stump-land into cultivation must be desirable.

Agriculture is, of course, the very backbone of the nation. It does not follow, however, that all agricultural practice is desirable. Let us say, rather that all *permanently profitable* agriculture is desirable.

[1]Report of Secretary of the Interior, 1918.

[2]The annual lumber cut of the country is around forty billion feet; the average cut per acre 5-10 M ft. b. m.

[3]For a typical instance see account of the Lincoln family experience, Tarbell, "Lincoln," Vol. 1, pp. 17, 45.

Attemps to farm lands which cannot return a decent living, or the farming of lands so as to lead to the ruin of the soil itself, as by erosion, are certainly undesirable on every count. "To the State, any kind of 'pauper' industry or industry in which people cannot make fair wages and a fair living, is an injury. Of these pauper industries, the farming of non-agricultural land is the worst.[4]

Logging proceeds rapidly. Even under very favorable circumstances, agricultural development follows lumbering at a tardy pace. Between lumbering and farming there is an average hiatus of decades, under present conditions, perhaps approximating fifty years. Where conditions are not favorable for farming, the interval is indefinitely extended.[5]

This situation places great burdens on the early settlers who need tax money for roads and schools and administrative expenses. These burdens are out of all proportion to the current value of their improved property. As a rule, therefore, timber being the only immediately valuable asset of the region, the timber owners must pay. Soon the tax rate forces the hurried cutting of the timber to prevent its confiscation by taxes. With less timber left, the tax rate must rise again. Presently the timber is gone and the new community must adjust itself to different conditions, economic, fiscal, social, as respects transportation and political preferment.

Not at all infrequently the result is the abandonment of whole towns and the practical desertion of whole counties.[6]

Erosion of lands, which should never have been cleared of their forests, results similarly in the deterioration and often in the complete destruction of farms and farming communities. This waste already amounts to more than 4,000,000 acres, the equivalent of 100,000 farms, or the complete bankruptcy of 100,000 farmers.[7]

The fatuous assumption that a farm can go wherever a forest can go is exhibited throughout the New England country—in the Appalachians, in the Ozarks and generally in mountainous regions. One can find old stone walls zig-zagging through the beech woods on the Palisades of New York and saw-log pine standing between old cotton furrows in the Carolinas. Jack-pine is now crowding into the clearings of thousands of deserted lake states farmsteads. It is seldom that such things are made of record. At best, direct records are sketchy and hesitating, but they are to be found.[8]

It would be interesting to inquire into the occasions for such reticence concerning farming failures. One may find libraries of reports upon slums

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[4]Roth, Forest Valuation, 1916, p. 132.
[5]Shattauck, Idaho Experiment Station Bulletin 91, 1916. Forbes, Proceedings Southern Logging Congress, 1917, p. 50.
[6]Dana, U. S. D. A., Bull. 638, 1918.
[7]U. S. D. A. Yearbook, 1916.
[8]Whitney, U. S. D. A. Report 70, 1901.
Report Commission of Inquiry, Michigan, 1908.
F. C. Howe, "High Cost of Living," 1918.
Dana, loc. cit.

and upon the economic wastes involved in wildcat industry, or the results of stock-watering by corporations, but there are only reluctant and usually inadvertent admissions concerning pauperized agriculture. Probably the explanation of the matter is the continued prevalence of the idea that all land must be in some manner of agricultural character; that it must be suitable for some farm crop, or at worst, for grazing. Back of, and with that idea, goes the feeling that if land is not suitable for agriculture of some sort, it must be worthless and therefore a perpetual liability, making of the community so afflicted an economic cripple before all the world. It is felt that to exhibit such a situation must be unkind if not malevolent.

The census, however, has no qualms. Thirteen states east of the Mississippi showed an actual decrease in the area of their improved lands between 1900 and 1910.

Through the census one may trace the blasting of the labors of tens of thousands of farmers and their families; the wrecking of their hopes and homes; the slow and painful degeneration of their social status, generation after generation, county by county, year by year. Why dissemble concerning these things?

Specific instances of variegated and unmitigated fraud in connection with "agricultural" lands are too common to attract attention. They are notorious and principally notable, in this connection, for their immunity from interference. It is strictly against the code to complain concerning an unfortunate investment, or to admit a faulty judgment concerning soil or climate; the local people must put as good a face upon their situation as is possible, insisting before the world that theirs is truly the garden-spot of the world, and that it makes no difference whether their Eden is eight thousand feet high on the Wyoming plains or in the swamps of the Everglades; whether it is in the flint of the Ozarks or the sand of the lake states. Save that of the prospector, there is no optimism greater than that of the settler who enters into a new region.

Nowadays, most new settlement is aided and abetted, not to say promoted and induced, by professional colonizers. These colonizers may be upright and conservative people intelligently building up profitable agriculture, or they may be the most reprehensible of the land-shark tribe. In either case it is obviously to their interest to expatiate upon the advantages of their project and to minimize the disadvantages. Up to the point where there is actual misrepresentation, business ethics are not offended. Beyond that point it is the function of the blue-sky laws to operate. Such laws are, for the most part, recent and experimental. They do not seem to apply, even indirectly, to land exploitation; here *caviat emptor* is still good law.

With local interests and the professional colonizers at least temporarily in accord, it is certain that the local politicians will be in line. Perhaps that may in a measure explain the failure of the blue-sky laws to reach this field.

Perhaps it also explains a certain marked reticence on the part of public officers where cut-over lands are concerned, and the studied avoidance by Federal and State agricultural institutions of topics seemingly within their legitimate purview, as for instance, deserted farms and abandoned farmers. One will search almost in vain for specific and candid statements upon such subjects. The hyperbole of the boomer is very commonly preferred to the sober style of the scientist.

The general code which tends to suppress the "knocker," the wholly understandable local sentiment resulting in political pressure, the power which exploiting "capital" normally has in a new region, account largely for the peculiar subreption which so often obtains in connection with "agricultural development." But there is another phase of the matter.

As the engineer hesitates to admit that he cannot harness any rapids, or, as the surgeon refuses to admit any limits to which his skill may not some time go, so the agronomist will not permit himself to be restrained. To the agronomist and the soil surveyor, land not under intensive cultivation is but a challenge. This is right and proper, and the justification for such a point of view can be amply supported. But the engineer will often say to his principal, "I can build you a dam that will hold—but it will cost you more than it is worth." Or, "There is a lot of ore in that hill, but it's of too low grade to handle at a profit." Under such circumstances, what does the agricultural expert say?

"We are close upon the limit of our resources and are asking where we shall find more land with which to supply our ever growing needs. * * * The dry-farmer * * * has reformed his tillage methods * * * and has chosen a * * * set of plants to help him * * * durum wheat, milo, kafir, kaoliang, * * * alfalfa." In the drained swamp areas we have "Kalamazoo celery, Wisconsin cranberries, the onions from Iowa muck lands * * * rice and dasheen. * * "We know that the hills of New England were pressed into flat-land uses by reason of certain peculiar circumstances and with the most melancholy results * * * In the Ozarks one may still * * * see a native farmer or his wife following a 'little ole rabbit mule' and an eight-inch plow up and down over stony hillsides which it was a crime even to have cleared * * * But those very hills are * * * suited to raising the finest of peaches and apples and strawberries * * * and man can fit upon the resources of this region a splendid type of diversified farming * * * And so on indefinitely."[9]

Michigan cut-over lands comprise "areas of two distinct types: Those on which hardwoods grew and those producing pines and other conifers. Stump lands, upon which hardwood grew, if promptly rough-burned and seeded to a mixture of grasses and legumes and then pastured for a few years until the

[9]Nourse, Scientific Monthly, Feb. 1918, p. 116.

stumps decay, may be rapidly and cheaply reclaimed for grazing and crop growing."[10]

"A larger portion of the sand lands of the state will undoubtedly be utilized than is at present anticipated. For this purpose, fruit growing is being restorted to where conditions are peculiarly suitable. These very light lands, instead of being farmed intensively in small areas, will some day undoubtedly be operated in large tracts and utilized for grazing purposes, when proper methods of handling, seeding and improvement are solved, which they surely will be * * * "[11]

"The sandy jack-pine plains of the lake states have long been an agricultural problem. * * * More people have left these lands during the last thirty years than are now living on them. * * * The problem has been whether these lands could ever be farmed profitably or whether they had not best be used for forestry purposes. The successes of numerous farmers in growing clover * * * on these lands indicate that a solution has at last been found. * * * This is a most fortunate circumstance. With clover for a start, either for seed or forage, the land can soon be built up into almost any state of productiveness."[12]

"The soils of upper Wisconsin are nearly all highly productive. There is variation in soil and subsoil, it is true, and there are portions which are not productive * * * but these occupy relatively small areas * * * For the average farmer, land that cannot be made to support good pasture in an ordinary season has a lower agricultural value than that upon which the maintenance of pasture is no problem. If the tract consists of coarse sandy soil, with a sand subsoil, difficulty will be found in getting and maintaining good pasture * * * Grass grown in the shade of brush furnishes very little nourishment to cattle, but sheep can get something out of it and pave the way for the dairy cow * * * While it may not be possible to make pork in upper Wisconsin as cheaply from October to April as during the summer months, the man who has not tested the value of roots, vegetables, clover, skim-milk and home-grown grain cannot tell today what the difference would be."[13]

One may not cavil at such offerings on the grounds that they are actually untrue or cannot become true with time, nor if they are offered with a view to mitigating the condition of the unfortunates who have guessed wrongly, or who have been deceived as to soil or climate or market. The development of agricultural technique has been real and very rapid, and it is idle to define its future limits. Considering the prehistoric accomplishments of the Peruvians or current farm practice in China, one might as well admit anything as possible for a modern agronomist. He may even be able to devise jitney plows,

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[10]What of the pine lands?
[11]M. A. C. Special Bull. 70, 1914, p. 9.
[12]U. S. D. A. Farmer's Bulletin 323, 1908, p. 5.
[13]Wis. Dept. Ag. Bull. 290, 1918, pp. 6, 9, 20.

free fertilizer, and a frost-proof epiphytic peanut. But, in the meantime, it is too much to insist that he differentiate between agricultural possibilities and economic probabilities? Might he even be required to demonstrate his thesis by actual accomplishment—accomplishment accompanied by the services of a competent accountant?

That Michigan, together with the rest of the cut-over land states, has great areas of potential farm land, is past argument. That the development of permanenetly profitable farming is to be encouraged in any manner practicable is a matter of course. But orthodox "agriculture" is not sacrosanct, and there has been much camouflage among its priests.

Three items in particular require more attention than has generally been spared them:

1. The first cost to the settler of logged-off lands.
2. The cost to the settler of clearing his stump lands.
3. The final results of farming the logged-off lands, measured in terms of real farms, fair averages, and over respectable periods.

First cost to the settler is often unreasonably high, because the owners of the cut-over lands are speculating. Acquired originally for their timber and without regard to the intrinsic value of the soil, any land value, per se, has usually been charged off against the stumpage,[14] so that if anything is later realized from the sale of the land, it represents an unearned increment, or is "velvet" to the owner. The Bureau of Corporations has proven to what an astonishing degree the ownership of our timber lands has fallen into a few hands and its epochal report observes: "When the timber has been cut the land remains. There has been created, therefore, not only the frame work of an enormous timber monopoly, but also an equally sinister land concentration.[15]

Just how this concentration in land ownership has affected Michigan is exhibited in some detail by the same Federal investigation, which shows that a single firm owns 1,473,000 acres in the state (some 250,000 acres of which were derived from agriculutral college scrip and state educational grant lands), while thirty-two owners possess nearly 6,000,000 acres, or about one-sixth of its entire land area.[16] Similar conditions obtain in other states. The results of such a situation as it affects agricultural development are yet to be canvassed in detail. The general results are obvious enough. It has been suggested that derived difficulties may be remedied through a revision in our taxing methods.[17]

The cost of clearing stump land has been but little investigated and still less written about, but recent reports show that it can seldom be accomplished

[14] Cut-over Land Magazine, Dec. 1918, p. 4; Jan. 1919, p. 16.
[15] Lumber Industry, 1913, Part I, p. xxii.
[16] Bureau of Corporations, "Lumber Industry," Parts II and III, p. 213 and map.
[17] Howe, "High Cost of Living."
Quick, "On Board the Good Ship Earth."

under conditions in the Lake States for $25 per acre, and that the costs may easily run to $150 per acre.[18]

A further very critical item has been but little considered in connection with the profitable farming of our stump lands. The fact that parts of Michigan have but a 70 days' growing season, and that practically all of the cut-over part of the state can depend upon less than 140 days,[19] is not much dwelt upon in our agricultural literature. In the past there has been almost a conspiracy to promote "development" of the cut-over lands, irrespective of whether it was economically sound or plain wild-catting. Conditions are changing rapidly. A member of the Society of Agricultural Engineers can now say to the promoters of cut-over land settlement, "There is no sense in the cut-over land owner trying to deceive himself, because profitable development must be based upon the lands as they are * * * The problem of the land owner is to determine whether his most profitable crop will be timber, (reforestation), cattle or sheep (grazing), or suckers (unwarranted land selling)...[20]

We no longer lack for specific inventory and analysis of the business of farming upon our cut-over lands. The office of Farm Management of the United States Department of Agriculture has reported in detail upon 801 typical farms of the north Lake States with the following results:

1. There was an average investment per farm of $6,856.

2. If there was no outstanding mortgage or other debt, and if 5% interest is allowed upon the investment, there remains as a labor income to the farmer an average of $40 per year, or 13.4 cents per day.

3. On 49% of the farms there was a *minus* labor income averaging $280, indicating that the farmer received no wages whatever, but did receive 0.9 of 1% on his investment as his year's return, provided he had no outstanding debts.

The Bulletin remarks, gratuitously, that "From a strictly business point of view these farms do not appear to the successful * * *" and that, "it is important, in all cases, to make sure that the quality of the land justifies the expense of clearing." [21]

As things stand, in spite of all the Federal and State homestead laws and in spite of the Experiment Stations, and in spite of the plant explorers, the the plant breeders, and the rest of the agricultural technologists, in spite of decades of experimenting, and in spite of boomers and booming, Michigan has today over 10,000,000 acres of idle land; the nation has an area ten times that of Iowa, in black stumps, and brush. And this area is increasing.

Admitting that great areas of the cut-over country are, or will become, of actual value for agriculture, it should be obvious that only a small fraction of the total can, by any chance, be reclaimed from its waste and come under

[18]M. A. C. Special Bull, No. 90, 1918, p. 28.
Wis. Ag. Coll. Bull. 259, 1918, p. 23.
[19]Seeley, Rept. Mich. Acad. Science, 1918, p. 223.
[20]Morse, Cut-over Land Magazine, June 1918, p. 6.
[21]U. S. D. A. Bull. 425, 1916.

cultivation within a given year, a decade—many decades. Every acre of farm competes with every other acre in the same crop; crop competes with crop, region with region. With but 49% of the total farm area in the United States "improved," and with our crop yield per acre lower than most of the world, and with the market for farm products so unsatisfactory as to cause a marked falling off in our agricultural population, the proposal for the reclamation of great areas of new lands, desert, swamp and cut-over, meets with little enthusiasm from agricultural economists. To the statement of the Secretary of the Interior that "There is enough unused land between the city of Washington and Louisiana to feed the whole United tSates abundantly, if that land were properly developed,"[22] the editor of our greatest agricultural paper replies: "Nobody knows about these lands better than does the farmer and the land investor. They would have been improved long ago if their reclamation had been a paying proposition * * * Some day some of these lands will be reclaimed—not all by any means."[23]

Irrespective of the percentage of land truly of agricultural value, but now incumbered with stumps, and irrespective of the rate at which the good lands are reclaimed, great aggregates of land of dubious agricultural character remain. It would seem obvious that there should be a segregation "between soils which can unquestionably be farmed with profit under present conditions and those concerning the farming, of which there is doubt."[24]

If lands cannot now be farmed with profit, does the fact that they will probably become available for farming in the future at all indicate that it would be unwise to devote them to grazing, if grazing can now be made profitable.? And if neither farming nor grazing is now profitable, and if no one can certify as to the time which will elapse before either becomes profitable, is that a legitimate reason for retaining scores of millions of acres in non-productive condition? Perhaps it is assumed that no other methods of profitable utilization are available. One cannot look at a stump field and announce that it can be made to produce cotton or potatoes, but one can say with certainty that where there are stumps have been trees, and that where trees have grown trees may grow again. Perhaps one may refuse to place timber trees in the category of crops. Or, it may be, one might consider the possible earning power of a forest crop as too little to receive consideration in comparison with farm or forage crops.

Such points of view would indicate gross ignorance rather than poor judgment. The agronomist must include the timber tree among the other crop

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[22]Country Gentleman Magazine, Feb. 15, 1919, p. 3.
[23]Country Gentleman Magazine, Feb. 1, 1919, p. 16.
[24]Soil Survey Vilas County, Wisconsin, Madison, 1915.
Sauer, 19th Rept. Mich. Acad. Science, 1917, p. 79.
[25]A forest which prevents erosion or which protects stream-flow above an irrigated district may pay its way generously even though it is never harvested. The recreation value of the National Forests is not less than $7,500,000 a year. (Waugh, U. S. F. S., 1918.)

possibilities, and with forest, as with farm, it is in fairness necessary to require that it pay its way in money or otherwise.[26]

If a timber forest is expected to pay its way in money it can do so, and on conditions quite comparable with the farm. The high-priced intensively farmed lands of the corn belt pay their owners a return of but 3.5% on their investment, plus reasonable wages.[27]

Well managed forests pay wages, plus interest on the investment, varying, in general, between 2 and 4%.[28]

It is not a question whether more or less artificial forests can be grown profitably in America. The question is only whether there is occasion to grow forests, or rather, how much forest should be grown.

At the current rate of timber consumption the standing (wild) timber forests of the United States are good for less than 55 years.[29]

The timber of the United States is being destroyed two and a half times faster than it is being produced.[30]

The cost of lumber has more than doubled since 1915, and costs are expected to increase indefinitely.[31]

The forests of the Northeastern, Eastern and Lake States are practically gone and their timber cut is today almost negligible.[32]

The Secretary of the Southern Pine Association (members of which own about 10,000,000 acres of cut-over lands) reports that within five years some 3,000 sawmills in the southern pine district will be cut out and gone and that the district's lumber production will decrease 50%.[33]

The President of the National Lumber Manufacturers' Association states that within five years the Pacific coast lumbermen will have substantially no competition save locally among themselves, and that the Pacific coast forests must then supply practically all the United States and a good part of the rest of the world.[34]

Save for the Pacific coast stands, there are no great virgin forest areas in the world except those of Siberia and the Amazon.[35] These are of a character ill suited to American needs, even if available.

The increasing cost of forest products, largely due to decreasing supplies, is already operating, together with other factors, to limit materially the domestic timber consumption of the nation.[36]

The amount of timber necessary to the economic prosperity of a modern agricultural and industrial nation is well known.[37]

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[27] U. S. D. A. Bull. 41, 1914, p. 42.
[28] Roth, Forestry Quarterly, June 1916, p. 257.
[29] Bureau of Corporations, "Lumber Industry," 1913, Part I, p. xix.
[30] Rept. Nat. Conservation Commission, 1909, Vol. 2, p. 223.
[31] Report No. 28, Price Fixing Committee War Industries Board, Nov., 1918.
[32] U. S. D. A. Bull. 673, 1918, p. 9.
[33] Rhodes, Lumber Trade Journal, Jan. 15, 1919, p. 19.
[34] Kirby, Lumber Trade Journal, August 15, 1918, p. 23.
[35] U. S. F. S. Bull. 83, 1910.
[36] U. S. D. A. Report 117, office of the Secretary, 1917.
[37] Fernow, "Economics," p. 38.

If it be urged that substitutes for timber are practicable, and that consequently the need for forest products tends to decrease, it may be shown that the forest area of France and Germany already amounts to between 20-25% of their total land area, and for many years has tended to increase, while at the same time both countries have been large importers;[38] that England, the greatest importer, is planning an immediate and enormous increase in her forests.[39]

If it be noted that concrete and steel have replaced much wood, it may also be noted that constantly new uses for wood are found, as, for instance, in the invention of "synthetic silk," made from wood pulp, or the use of wood-cellulose to replace cotton in nitro-explosives. In this connection it may be pointed out that cellulose chemistry is in its infancy, and that the forest produces a greater dry-weight of material per acre per year than any other crop,[40] and, at that, on poorer sites and at less expense. If probabilities of the future are in question, the forester will race his old spruce against the agronomist's new peanut.

In 1850 the world had no similar forest area of intrinsic value equal to that of this state's pineries. For thirty years this state led the world in the quantity and quality of its lumber output. Today the timber yield of the state is negligible; the state imports much more timber than it cuts, and cuts much more timber than it grows.

Pine is coming into Michigan from Arkansas, Mississippi and Montana; oak is coming in from Tennessee, Indiana and Virginia; redwood from California and cypress from Louisiana; fir from Washington, and cedar from British Columbia. These are not mere odds and ends of importations, but enormous aggregates, representing millions of dollars, and as essential to the conduct of the domestic affairs of the state as steel or coal or copper. Grand Rapids furniture is made from lumber shipped an average of at least 1,000 miles; Detroit automobile wheels are largely made from hickory grown and cut in the South and shipped half across the continent. It is as though, within fifty years, Iowa could no longer supply herself with corn, as though California must go to Florida for oranges; or as though the Keweenaw brought in its ores from Butte.

Michigan's freight bill on imported forest material[41] alone is enough to reforest 500,000 acres a year.

If it is certain that no modern nation can prosper industrially without forests, it is still more certain that no nation can make successful war without forest products. The war tested out in a very thorough manner the essential items among our resources and manufactures. The winning of the war was as dependent upon the forests of France and America as upon the coal or

[38]U. S. F. S. Butt. 83, 1910.
[39]Graves, Journal of Forestry, Feb. 1919, p. 116.
[40]Fernow, "Economics," p. 132.
[41]Graves, loc. cit.

steel or wheat, and without those forests the war was most certainly lost. Ships in a hurry? Millions of feet of long leaf pine and Douglas fir, pinned locust and live-oak and calked with pine pitch. Cypress lifeboats with oars of ash and spruce.

Air and hydroplanes? Ash for alierons, spruce for wing-beams, maple and birch veener for fusilage, cedar for pontoons, wing "dope" cut in acetone and propellers of walnut and quartered oak.

Artillery? Wheels of oak, wooden escort wagons. Shells? Machined with high-speed tools made from charcoal iron; shrapnel bedded in rosin.

Infantry? Their rifle butts were of walnut; their clothes were dyed with osage-orange; their shoes were tanned with extract of hemlock and oak bark and chestnut wood; their trench tools were handled with hickory and ash and maple; their gas masks were filled with charcoal from the shells of nuts; their supplies were shipped in wooden containers and their rations were put up in fibre packages.

Hospital supplies? Chloroform and iodoform come from the products of wood distillation.

Dugouts and trenches? Shored up with timber. Roads impassable with mud? Curduroy and puncheon. Telescopes and range-finders? Their lenses were mounted in Canada balsam.

Cavalry? Saddle trees were of basswood, stirrups of ash.

Was anything more essential than England's coal? The worst phase of the English coal situation was in the getting of pit-props.

Did great sections of the United States verge upon utter disorganization and calamity for lack of fuel? The local woodlots came to the rescue when nothing else could have come. Did Germany lack for cotton for textiles and explosives? She used a wood pulp base and went on.

Must a half dozen new ports be equipped, harbor works, docks and warehouses complete within a few weeks? Put a regiment of American foresters and lumber-jacks into the old French forests and the necessary piling and lumber is on hand in time. No other materials could have done such work; none other could have been gotten in time.

The list goes on indefinitely. Uncover the machinery of war at any point and there the forest will be found at work.

In war or in peace it is not a question as to whether there should be forests, or what kind of forests or where or how many. Save in abnormal times one does not argue thus concerning wheat or corn. With them, supply and demand regulate price and price regulates supply and the supply is forthcoming from those lands which can most economically produce wheat or corn. Within a few months a new crop can make good a previous deficit; a surplus results in restricted acreage in the succeeding year. The carry-over and the production period with usual crops involves but a few weeks, and within a relatively few weeks great stimulation results in great crop increases. But a

timber crop cannot be improvised at need. Fifty or a hundred years are required to mature a timber crop. When once a deficit in timber makes its appearance, there comes a very long period before the deficit can be made good. The deficit has made its appearance. Directly, it will be obviously serious where now it is only apparent.

In the meantime we have some 228,500,000 acres of stump land idle, deteriorating, non-productive; a menace and a liability. In the meantime the boomer booms and the sucker bites, and for every few newly reclaimed acres other ex-forest and ex-farm acres revert to brush or travel away down the rivers.

The "doctrine of highest use" is too well established to require argument. Its application is simple enough. There should at once be a classification of the idle lands of the country for the purpose of segregating those which can undoubtedly and under present conditions support a profitable agriculture from those lands on which agriculture is now unprofitable or dubious. Let us make it possible for the bona-fide farmer to have a fair chance at the lands which give a fair chance. Let us then put the rest of the logged-off wilderness to work under forest, pending that time when changed conditions or new methods permit the land to be still more profitably utilized.

Over vast areas where land quality runs unevenly, the forest will be the complement to the farm exactly as the range now complements the ranch, as Europe has proven for five hundred years.

There will be no controversy between the real farm and the real forest. There will, however, be controversy over a system which permits an empire of ex-forests to lie fallow, or spawning pauper farms, to the confusion of the innocent, the increment of the absentee landlord, the impoverishment of the state and the hazard of the nation.

Univ. of Michigan, March, 1919.

SOME PHYTOGEOGRAPHICAL OBSERVATIONS IN LAKE COUNTY, MICHIGAN.

BY LEROY H. HARVEY.

The northern half of the Southern Peninsula represents to the phytogeographer an interesting problem in classification. Viewed in the main from the floristic standpoint, it has received various disposition. Transeau ('05) considers it a part of the northern coniferous forest; Harshberger ('11) includes it in his Interlacustrine Area of the Lake District; while Shreve ('12) maps this area in his Northern Mesophytic Evergreen Forest, concerning which he states: "This extensive region is characterized throughout by a pure or nearly pure stand of needle-leaved evergreen trees, among which deciduous trees are often present either as minor components of the forest or else as trees of minor stature. * * * In the eastern portion of the area the white pine (*P. strobus*), *the hemlock* (*Tsuga canadensis*), the jack-pine (*P. divaricata*), and the balsam fir (*Abies balsamea*) are the most common species." This phytogeographic area he delimits as distinct from his Northeastern Evergreen-Deciduous Transition Forest.

To one at all familiar with the region under discussion the inadequacy of such a classification from the standpoint of ecological plant—geography is strikingly apparent. Within the history of man the needle-leaved evergreen forest probably never did predominately occupy very extensvie unbroken areas within this region. Limited stands of the big pines were interrupted by more extensive areas of the jack-pine, the mixed jack-pine oak, and the black-white oak formations. All along the eastern and western boundaries of the southern peninsula and scattered throughout the central area there existed extensive stands of the hardwood or mixed hardwood formation. It is thus evident that ecological conditions permit in certain widely distributed areas over the entire region the development of the deciduous climax forest type for eastern North America, either as the pure maple-beech or mixed hardwood association.

Our region thus represents a great tension zone in which the northern outposts of the deciduous climax forest formation and the southern relicts of the northeastern evergreen forest formation overlap and intermingle, thus becoming competitors for occupation. So nicely balanced are the controlling factors that in many areas one fails to find any evidence of the usual successful sequence, while factorial interpretation of present distributional conditions is well nigh impossible. If considered, however, in light of the postglacial migrations (Adams '02) and with an early pre-occupation of the several enviromental

complexes by the now distinct forest types we may at least get a plausible explanation of the problem. Without doubt certain successional stages ensued, but it seems highly improbable that the full gamet of forest associations was run in any case, not even in the maple-beech climax series, and in most cases succession was decidedly abbreviated or entirely lacking, as was probably the case in the big pine association. In short, the original distribution of the upland forest associations appears to have been more the result of preoccupation and subsequent self-perpetuation than of a well-marked successional development.

These conditions are well exemplified in Lake county. Within a radius of some fifteen miles from Little Manistee are to be found five types of upland forest associations—the big pines, the jack-pine, the jack-pine-oak, the oak and the mixed hardwood. Observations would seem to indicate that under natural conditions each of these types is essentially self-perpetuating. The only possible successional development would be that resulting in the jack-pine and jack-pine-oak passing into the pure black-white oak formation. If freed from the influence of fires and cutting my observations would seem to indicate an almost interminable duration of the mixed jack-pine-oak association for reseeding of the former species goes on abundantly. It is, however, recognized that the jack-pine is a tree of shorter duration and more subject to disease than the oaks, and this would of course work in the direction of elimination of the former. Under artificial conditions the above postulated succession is being rapidly accomplished and the jack pines will soon be a thing of the past. Also under the influence of similar artificial factors the big pines have a similar termination. It should also be noted that the jack pines rarely exist in a pure stand of any extent, but rather as impure bands or isolated islands among the oaks. On the other hand, I have never seen in this region a pure stand of the oaks which was unquestionably the result of natural successional development.

An ecological classification should be based upon original conditions insofar as we may be able to reconstruct them. To this end the month of August, 1918, was spent in this region and an intensive study of soil and atmospheric conditions was carried on. The results at hand fail to show any soil or atmospheric conditions of sufficient gradient to explain present forest distribution or to give any indication of casual successful factors. The following table of moisture holding capacities of a series soils taken at a depth of 25 cm. and determined on the basis of equal volumes according to Hilgard's method ('06) shows clearly the inadequancy of the soil factor, as it reveals no soil differences of casual magnitude.

TABLE 1. MOISTURE HOLDING CAPACITY.

Station.	Association.	M. H. C. % of Dry Weight.
A.	Maple-Beech, Kalamazoo (for comparison)	62.1
5.	Jack Pine	42.7
11.	Jack Pine	41.3
4.	Jack Pine-Oak	41.7
3.	Oak	42.7
6.	Big Pines	41.8
7.	Big Pines	43.7
9.	Big Pines	43.1
14.	Big Pines	40.7
15.	Mixed Hardwood	42.5
13.	Mixed Hardwood	41.7

Similar conclusions would seem to be justified from the following average daily evaporation data:

TABLE 2. AVERAGE DAILY EVAPORATION. AUG. 4–AUG. 31, 1918.

	Association.	No. Stations. No. Atometers.	Evaporation.	Range.
1.	Standard (Maximum)	2—2	19.4 cc	19.3—19.5 cc
2.	Big Pines	7—11	12.79 cc	8.3—18.6 cc
3.	Oak	2—2	19.0 cc	18.4—19.5 cc
4.	Jack Pine-Oak	2—2	17.5 cc	16.7—18.4 cc
5.	Jack Pine	1—2	12.7 cc	12.2—13.2 cc

The lower average daily evaporations in the big pines and in the jack-pine association is due not to the effect of the canopy, but entirely to the sheltering effect of the herbaceous and shrubby layers. This is evident in the great average daily range of from 8.3 cc to 18.6 cc (124%) in the big pines, corresponding as these rates do with the maximum and minimum of protection from the influence of air currents. On the other hand, by the selection of stations similarly protected from wind influence records equally low could be readily obtained in the jack pine-oak and oak associations. On the basis of these results it would appear entirely unwarranted to assign evaporation as a casual factor in succession, thus econfirming the results of Gleason and Gates ('12, '17) and raising a question as to the validity of Fuller's claim ('11, '14) that "the differences in the rates of evaporation are sufficient to indicate that atmospheric conditions are efficient factors in causing succession," at least in this region.

In the introductory paragraphs, attention was called to the inadequacy of any existing classification of the plant formations. Upon the basis of the observational and experimental results just presented, which are mutually supportive, the following ecological classification of the upland plant formations of this region is proposed.

THE UPLAND VEGETATION OF LAKE COUNTY, MICHIGAN.

The Deciduous Forest Climatic Formation.

I. The Regional Climax Association Type.
   The Climax Forest Mixed Hardwood Association.

II. The Edaphic Formation—Complexes of the Region.
   a. The Yellow-White Pine Complex.
   b. The Black-White Oak Complex.
      1. The Jack Pine Association Complex.
      2. The Jack Pine-Oak Association Complex.
      3. The Black-White Oak Association Complex.

It is thus contended upon ecological grounds that any region should be classified upon the basis of the highest ecological type which may find expression therein. Upon this basis the southern peninsula should then be considered as a northern extension of the deciduous climax forest formation. This classification also establishes the existence of edaphic formations—two of these are here recognized, viz.: the yellow-white pine and the black-white oak formations. Further field work may make it seem desirable to include the jack-pine association in the same category. At the present time, however, it has seemed best to include it as the initial stage in the black-white oak complex.

Nichols ('17, '18) has reached similar conclusions relative to the edaphic formation complex on the basis of his work in Cape Breton, but his inferences rest mainly upon field observations. In 1910 I expressed a similar conclusion before this section relative to the oak formation of south central Michigan. It would seem that we now have in the above data adequate experimental demonstration of the regional edaphic formation, which under natural conditions will remain definitely self-perpetuating and successfully maintain itself against a successional invasion of the regional climax association, the mixed hardwood association. If these conclusions are substantiated by further field and experimental results, it is obvious that we must reconstruct our conceptions as to succesion and the ultimate domination of a regional climax formation within the geographical limits of extensive transitional zones.

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LITERATURE CITED.

Adams, C. C. 1902. Postglacial origin and migrations of the life of the northeastern United States. Jour. Geog. 1:303-310, 352-357.

Fuller, G. D. 1911. Evaporation and plant succession. Bot. Gaz. 52: 193-208. 1914. Evaporeation and soil moisture in relation to the succession of plant associations. Bot. Gaz. 58:193-234.

Gates, F. C. 1917. The relation between evaporation and plant succession in a given area. Am. Jour. Bot. 4:161-178.

Gleason, H. A. and Gates, F. C. 1912. A comparison of the rates of evaporation in certain associations in central Illinois. Bot. Gaz. 53:478-491.

Harshberger, J. W. 1911. Phytogeographic survey of North America. In Engler, Die Vegetation der Erde. 13.

Hilgard, E. W. 1906. Soils. New York.

Nichols, G. E. 1917. The interpretation and application of certain terms and concepts in ecological classification of plant communities. Plant World, 20:305-319, 341-353.

1918. The vegetation of northern Cape Breton Island, Nova Scotia. Trans. Conn. Acad., Arts and Sci., 22:249-467.

Shreve, f. 1917. A map of the vegetation of the United States. Geog. Rev. 3:119-125.

Transeau, E. N. 1905. Forest centers of eastern North America. Am. Nat. 39:875-889.

A STUDY IN THE DIFFERENCE IN SOIL REQUIREMENTS OF PINE AND SPRUCE.

L. J. YOUNG.

An area on the Saginaw Forest, planted to Norway spruce in 1904, has furnished an interesting and instructive demonstration of the great importance in forest planting of choosing the proper species with reference to a given combination of site conditions. In order that the business of forestry shall yield a profit, the rate of growth of the timber must not fall below a certain minimum. The more it exceeds that minimum up to a reasonable limit, the higher the profits. The proper species for a given site is, then, one which will make the growth demanded by the general economic conditions existing on any particular forest. To determine the right species is not always easy, and in the case of this particular area a mistake seems to have been made, for the growth over a considerable part of it has been far from satisfactory.

At the southern border a narrow strip is practically level, and here the growth of the spruce has been fairly good. To the north of this strip the land slopes moderately toward the lake, and this slope comprises most of the area. Here the growth has been poor, and on several spots *very* poor. At the foot of the slope is a slight depression, which runs toward the east, becoming somewhat deeper in that direction, and all the trees in the bottom of this have made excellent growth. To the north of this depression the land rises a few feet into a rounded knoll and here again the growth has been very poor. The result of these varying conditions is a very irregular stand, in which the present height of the trees varies from a minimum of 0.8 of a foot to a maximum of 21.1 feet, with an average of 6.5 feet.

Up to the time of its acquisition by the university, this land had been handled as a part of a farm and apparently had received little care, so that the surface soil on the slope had washed badly and three large gullies had been formed by erosion. The best of the soil from the slopes and the knoll to the north had been carried into the depression at the foot of the slope, forming a deposit of fine loam six inches thick without any admixture of gravel. On the slopes, coarse gravel occurs plentifully in the soil from the surface down.

Examinations of samples taken from different parts of this area showed that the soil on the slopes contains less moisture, very much less organic matter, and less lime than that from the more level portions. Undoubtedly the lack of these important plant foods is largely responsible for the unusually

poor growth of the trees on the slopes. It is noteworthy, however, that even the better portions of the area are so poor that the grass cover established between the trees has always been very thin and scant.

It has long been known that the pines as a class are more frugal than the spruces, i. e., demand less from the soil, in order to make an equal growth. To demonstrate this fact and to secure data for making a definite comparison between pine and spruce on the one hand and different species of pine on the other, three species of pine were planted in the spring of 1915 among the spruce on the spots where the spruce had made the poorest growth. The species planted were *Pinus strobus*, *Pinus sylvestris* and *Pinus ponderosa*. The ages of the stock were as follows: *P. strobus*, four years; *P. sylvestris*, three years; *P. ponderosa*, two years.

The height of all the trees on these plots was measured in March, 1919, after four growing seasons, for the pine and fifteen growing seasons for the spruce. The results of these measurements are shown in the following table:

Species.	—Total Height in Feet— Maximum.	Minimum.	Average.
Norway Spruce	7.0	0.9	2.88
White Pine	3.1	0.4	1.3
Scotch Pine	5.1	2.2	3.8
Western Yellow Pine	2.0	0.5	1.1

Since the growth of all of these species is relatively slow during about the first five years after planting, the pines have not yet had a fair chance to show what they can do. At the end of the next five years the differences will undoubtedly be much more striking. But even within the short space of fours years the Scotch pine has been able to make an average total height growth that is one foot greater than that made by the spruce in fifteen years, with a minimum height more than twice that of the spruce.

If the different species are compared on the basis of the average annual height growth made since the germination of the seed, these results are obtained:

Species.	Average Annual Height Growth in Feet.
Norway Spruce	0.17
White Pine	0.16
Western Yellow Pine	0.18
Scotch Pine	0.54

During the years to come the average annual growth of all the pines may be expected to increase decidedly while that of the spruce will probably decrease. Just how much the growth of the pines will increase and which one of the pines will be leading at the end, time only will tell. The present figures are merely indicators, but already emphasize the wide difference between the Norway spruce and Scotch pine in adaptability to poor soil conditions.

The coniferous forests of Europe are composed almost entirely of Scotch pine and Norway spruce, so that a great deal is known as to their rate of growth under European conditions on sites of different qualities. It is interesting to compare their figures with the ones given above as a means of eval-

uating the quality of the site under discussion. The average annual growth of Norway spruce for the first fifteen years (this period is taken from the time of planting) on sites of the poorest quality used for spruce is 0.23 of a foot. Our growth has been 0.19, which shows that these poorest spots are somewhat lower in quality than the poorest spruce sites of Europe. Using the pine figures in the same way shows that these same spots correspond almost exactly to the medium, or average, quality of sites used abroad for Scotch pine.

Taking the growth of the spruce for this plantation as a whole, however, we find that it is nearly equal to that of sites of medium quality. If Scotch pine had been planted over this whole area, it doubtless would have made even better growth than the average of the best pine sites of Europe. Speaking technically, this means that by growing spruce on this area we are working with Site II; in pine it would be Site I. The European growth figures for these sites at the end of 120 years are:

Scotch Pine.	Average diameter, 15.4 inches.
	Average height, 103 feet.
Norway Spruce.	Average diameter, 11.5 inches.
	Average height, 84 feet.

In 1924, at the time of the next measurements, we shall be able to predict more definitely the probable growth of the white and western yellow pines, a thing that we are unable to do at present because of their habit of starting more slowly than the Scotch pine.

University of Michigan.

THE BIOLOGICAL METHOD OF DETERMINING THE FERTILIZER REQUIREMENT OF A PARTICULAR SOIL OR CROP.

R. P. HIBBARD AND S. GERSHBERG.

Soil experts and chemists are loath to put any dependence on the result of a chemical analysis of either the crop or the soil as far as using them to plan a fertilizer treatment. The best and only logical way, then, to determine the crop's needs is to grow the crop on the soil and make a detailed study of the relations between the two. The great majority of fertilizer experiments have not been so planned. The combinations or ratios of the three fertilizer constituents commonly used have been greatly restricted, and except in a few cases the soil has been ignored.

The method suggested here consists in a well planned series of combinations, each one varying from the other and all the rest in small increments. In this way a wide range of ratios or combinations are used and there are no missing ones in the whole series. Obviously this is a more logical method than the hit-or-miss one, in which the combinations are selected at random.

To indicate the method by which a series of combinations is planned, since space for a figure is not available, one must picture to himself an equilateral triangle, the kind that has often been used when one desires to express in a diagrammatic manner the relations between three variables or three quantities, such as the three fertilizer salts, acid phosphate, sodium nitrate and potassium sulphate. This particular triangle which we wish you to think of indicates at the points of intersection of the various lines all the possible combinations or ratios of the three salts, where each constituent varies from the other by increments of ten per cent. There are eight horizontal rows of combinations, counting from the base to the apex of the triangle. In the lower row there are eight combinations; in the one above, seven, and in each succeeding row one less.

Many such series or sets of combinations have been arranged for water cultures in the greenhouse. This same method can be used in the field, but when the plots are large, as for example one-twentieth of an acre, the work would be difficult and almost impossible. However, the plots can be cut down to small sizes and a number of checks or controls introduced to average up individual differences. Then at the end of the experiment the undesirable combinations can be eliminated and the others run on plots of larger size. Another way to obviate this difficulty would be to run a series with few numbers of combinations. Let the combinations differ in increments of 20 per cent.

In the summer of 1918 a complete series of 36 combinations, run in triplicate, was put out on the station farm. The experimental plots were 2 feet by 40 feet. Besides the 36 combinations of three fertilizer salts, there were several

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plots on which applications of single salts and double salts were made. Here and there scattered through the series were check or control plots. The soil was a sandy loam and the crop oats. At the end of the experiment the best combination of fertilizer salts was determined by the yield of grain and straw. Although it is hazardous to judge from one season's work, the results indicate that the best combination is that in which there is a large amount of acid phosphate. This is true only for this particular soil. The plot that was treated with acid phosphate alone, however, did not yield as well, showing that a small amount of the other two fertilizers was needed. A subsequent experiment should consider the ratios in this region of the triangle in more detail and on larger plots. With another crop on another type of soil, some other ratio might be the best. These matters have yet to be determined. Three experiments are now running: One on the college farm with oats on a poor sandy soil; one at Clio, Michigan, on the farm of L. J. Reed with corn on sandy loam; and the third on the farm of Ezra Levin with potatoes on a fine sand, containing only a little organic matter. It is the hope of this article that others will be interested to work out their soil and crop needs by the ratio method. If so inclined one could collect a large amount of a certain soil type in the fall, and during the winter set up some such series as outlined above. In this way the preliminary work could be done away with and a small series run on a large scale in the field in the spring. The farmer, not inclined to study the soil because of inadequate apparatus and supplies, could send the soil samples to a laboratory, where such a study as outlined above could be made and from the data collected a method of treatment devised and forwarded to him.

It is believed that three or four weeks' growth of plants in pot cultures will give data which can be used to predict the probable yield at maturity. In fact, there is every likelihood that a mathematical scheme can be worked out to show what the final yield will be after merely a few weeks of growth. Thus in the winter time one can wisely plan what sort of combination will be best to use for a particular crop on a particular soil. Truck growers who use large greenhouses have excellent facilities for working out such a method which will aid them in planning the fertilizer treatment of their soils in the field.

In conclusion it may justly be said that chemical analyses of soils and crops have taught us much in some lines, but little or nothing as to the fertilizer requirements. The crop test method is the only reliable one left, and if a wide range of combinations are selected and logically worked out, something definite and tangible can be obtained. There are great possibilities for improving our practice in the utilization of fertilizers in plant production. We need exact knowledge as to the best salts to use together and the best ratios or combinations.

Michigan Agricultural College.

CORRELATION OF VARIATION IN RESIN CONTENT OF PODOPHYLLUM WITH CERTAIN HABITATS.

W. R. M. SCOTT AND E. J. PETRY.

In an attempt to correlate ecologic factors with economic production of the resin of Podophyllum the writers have made a study* of resin content in three different habitats. No attempt was made to determine relative potency of the resins from these habitats, i. e., potency or medicinal value was assumed to be uniform.

On account of the rising prices of extracting reagents and cost of collec- given amount of material and a minimum amount of labor in collecting tion it seemed desirable to find out if the ultimate cost of production might not be lowered by determining which habitats would give most resin for a rhizomes.

In the conclusions arrived at, no allowance for the variable intelligence of collectors is made. The three habitats varied as to shade, air movement, soil moisture and humus and associated plants, while the soil had essentially the same origin. The plants used bore no fruit, so that it was possible to eliminate the effect of fruit bearing on the resin content. Colony characteristics and their ecologic factors will be enumerated below.

The methods of extraction were those given in United States Pharmacopoeia, 9th ed. (1916), with such refinements as would completely exhaust the material and constantly recover the maximum amount of resin from the alcoholic extract. This, in the first part of the extraction, involved the use of filter paper in soxhlet tubes (without heat) and more alcohol than is commonly recommended. The alcohol added to each extraction had not been previously used; i. e., it was poured on from above. The tubes were carefully washed with alcohol after the extract showed no further miscrocopic or chemical traces of resin in the last extraction siphoned off. This is necessary in order to recover traces of resin which tend to climb up the glass sides of the tubes.

The alcohol was evaporated at a temperature just below its boiling point, until the extract was less viscous than that recommended in the United States Pharmacopoeia, both on account of the difficulty of removal for precipitation, and because the dark color of a denser extract indicated a condition which might affect the ease of preciptation and amount of resin recoverable, if not indeed the quality of the resin. It would seem that concentration of the

*Thesis, in part, submitted for degree of M.Sc., Purdue University, 1918, by W. R. M. Scott.

extract might best be carried out in vacuo, but sufficient apparatus was not available.

Precipitation was carried out very carefully—all vessels having been weighed and microscopically inspected for traces of resin and all acidulated wash water was tested for traces of resin to see if any was lost. Fortunately, a means was at hand for controlling to a nicety the temperature, which is such an important matter in the precipitation of this resin. This was carried out in the intermediate room of the dairy refrigerator, whose temperature (10° C.) remained invariable during cold and warm weather. The precipitated resin was dried at 95° C. for a few minutes, then raised to 98° C. and held at this point for a half hour till a fairly constant weight was obtained.

HABITATS AND CHARACTERISTICS OF COLONIES SELECTED.

The first colony designated by 1 a and 1 b in Series I and II of the following tables was located on a 15° slope and received direct sunlight till noon, and diffuse light (thin shade of white oak) for two hours longer. It is in an exposed place with constant air currents and slight crowding by herbs and trees. The second colony, 2 a and 2 b of Series I and II of the tables, was on a steeper slope (25-30°), with fewer trees of the same species (white oak and hickory) as those of colony one. These formed a thin shade for only short periods throughout the day. Crowding by other plants, e. g., herbs and trees, was absent, while in number one this may have been a growth factor.

Colony three, 3 a and 3 b of Series I and II in table, was about 60 feet lower than the above two, but air movement was not as great as in colony two, which in turn is exceeded by colony one in this respect. The slope of the soil in this colony was like that of colony two, but the humidity was doubtless much greater on account of more dense forest of considerable extent in all directions. From the work of Gleason and Gates,[1] one may infer a lower transpiration, which could perhaps constitute an important factor in the limited growth of this colony referred to below.

Colony three had a diffuse light angle of 30° and a dense shade angle of 60°, the hills on the east and west cutting off the sun completely during the rest of the day. These angles were accurately measured and the total amounts of light energy received by the different colonies were calculated.

On an absolute scale, colony one received approximately 60 per cent of the full amount of light energy possible in that latitude and altitude; colony two received about 85 per cent, and colony three less than 35 per cent. This may not be an accurate measure of amounts of light used since in colonies one and two, more light may have been furnished during the unshaded hours than the plants could use, so that the ratios of amounts of light used in metabolism are undoubtedly not so wide as the above percentage would indicate.

The rhizomes were carefully dug, washed and dried with about three

[1]Gleason, H. A., and Gates, F. C. A Comparison of the Rates of Evaporation in Certain Associations in Central Illinois. Bot. Gaz. 53:491, June 1912.

inches of the fibrous roots attached. No diseased or decrepit stems or roots were taken. Three-hundred-gram samples were taken at random throughout the colonies and were air-dried to constant weight in a warm room. They were then ground to pass a 60-mesh sieve and transferred to tightly stoppered bottles. The mill was carefully washed with 85 per cent alcohol before and after grinding each sample, to free it from resin which collected on the buhrs to a noticeable extent in some samples. Rhizomes of colony three were smaller and easier to grind than those of the other colonies.

Hygroscopic moisture of the air-dry samples was obtained with two-gram samples at 98°—100° C., and the percentage calculated to air-dry basis for convenience in comparing percentages in the air-dry or crude drug condition (Table 1). For ash determinations one-gram samples were heated in a muffle for 45 minutes and calculated to air-dry drug. (Table 2). The nitrogen was estimated by the official Gunning-Cooper[2] method with one-gram samples and calculated to air-dry drug.

SOIL ANALYSES.

While the soils of the three colonies were essentially the same in origin (Knox Silt Loam)[3] it was nevertheless considered desirable to determine the "acidity" (lime requirement per 6-inch acre), total nitrogen, total volatile matter, and total moisture in order to enable us to detect any wide differences in growth which could be referable to the soil factor. An example of average conditions found is incorporated in Table 3.

The methods and data are here given very briefly, since the differences in data are considered to be insufficient to cause any noticeable effect in the growth of these colonies.

Total moisture and volatile matter were determined on 5-gram samples of well mixed samples and calculated to oven-dry basis.

After drying to constant weight at 99°—100° C. and noting loss in weight, the samples were ignited to redness for one hour in a muffle, and after cooling in a dessicator were again weighed and loss noted and calculated to oven-dry basis. After ignition, the soil had a bright red color throughout, whereas its natural color is a yellowish brown or gray if fertile. Total nitrogen was determined by the official Kjeldahl[4] method, modified to include nitrates, one-gram samples being used and amounts calculated to pounds, in a 6-inch acre.

These soils were slightly acid to litmus, and this was confirmed by determining the amount of tenth-normal potassium hydroxide required to neutralize 100 grams of soil after being shaken three hours with 250 c. c. of normal potassium nitrate, according to the method used by Hopkins and Pettit.[5] As noted in Table 3, the acidity was slight (200-300 pounds of lime per 6-inch acre

[2]U. S. Department of Agriculture, Bur. of Chemistry, Bull. 107 (revised).
[3]Tippecanoe County (Ind.) Soil Survey Map, Bur. of Soils, 1915.
[4]U. S. Department of Agric., Bur. of Chemistry, Bull. 107 (Revised).
[5]Hopkins, C. G., and Pettit, J. H. Soil Fertility Laboratory Manual. Ginn & Co., 1910.

required) in all soils, and it probably had no effect on the plants, which in this species tolerate a wide range of reaction.

Two collections of plants were made to see if any variation existed in the concentration of resin. These are designated in Tables 1 and 2 as Series I and II, and correspond to the dates, October 4th and November 3rd. The data show that October 4th was the time of higher concentration, and agree with data of Miller.[6]

[6]Unpublished data kindly furnished by F. A. Miller, Manager of Eli Lilly Co., Biological Laboratories, Greenfield, Ind.

TABLE 1

Air-dry and Total Moisture, Resin, and Nitrogen in Drug

Series, sample, and check numbers	Moisture grams. 2 gram sample	Per cent. water air dry drug	Per cent. water lost in air drying	Per cent. total moisture	Total resin grams 5 gram sample	Average per cent. resin air dry	Per cent. nitrogen air-dry (1 gram sample).
SERIES I							
No. 1a	.1317	6.58	36.36*	40.61*	.1950	3.88	1.20
" 1b	.1317				.1920		1.18
" 2a	.1282**	6.75	40.39*	44.21*	.1580	3.21	1.00
" 2b	.1280**				.1625		1.01
" 3a	.1245	6.26	46.75*	50.18*	.1950	3.86	1.09
" 3b	.1260				.1910		1.08
SERIES II							
No. 1a	.1315	6.50	61.8	64.28	.1840	3.47	1.23
" 1b	.1283				.1835		1.06
" 2a	.1400	6.81	63.56	66.04	.1525	3.09	1.03
" 2b	.1322				.1560		1.03
" 3a	.1350	6.77	65.70	68.02	.1830	3.48	1.12
" 3b	.1358				.1825		1.06

*Partly dried in transit.
**Redetermined.

TABLE 2

Ash in Drug (air-dry basis).

Series sample and check.	Total ash, grams	Per cent. ash, 1 gm. sample	Per cent. (average) ash in resin	Per cent. ash in exhausted drug, 5 gms. sample
SERIES I				
1a	.0485	4.85	1.05	4.03
1b	.0465	4.65		3.98
2a	.0500	5.00	1.50	4.09
2b	.0475	4.75		4.04
3a	.0595	5.95	.85	4.54
3b	.0560	5.60		4.61
SERIES II				
1a	.0505	5.05	1.01	4.34
1b	.0405	4.85		4.16
2a	.0490	4.90	1.56	4.32
2b	.0490	4.90		4.22
3a	.0470	4.70	.79	4.27
3b	.0465	4.65		4.19

TABLE 3

Soil Moisture, Nitrogen, Volatile Matter and Acidity.

Soil No.	Per cent. Total moisture	Per cent. (average) hygroscopic moisture	Nitrogen pounds per acre 6″+. soil	Per cent. volatile matter air-dry	Acidity
1a	20.54	2.41	3584.	5.39	Very slight
1b			3636.	5.38	"
2a	17.14	5.11	4060.	6.14	"
2b			4004.	5.86	"
3a	21.75	4.56	3920.	5.86	"
3b			3976.	6.02	"

CONCLUSIONS.

The following conclusions are derived partly from the data in Tables 1 to 3 and partly on phenological and collection data not fully noted previously.

1. It will be seen that sunlight as a growth factor varied greatly. It was most favorable for the growth of *Podophyllum peltatum* in colony number two, as judged by total annual growth of rhizomes and numbers of branches.

2. Conversely, the largest amount of light has a limiting effect on the relative amount of resin and nitrogen content, as shown by colony number 2, Table 1.

3. Total nitrogen of soil and other factors, e. g., fewer competitive plants also favor larger rhizome growth in colony 2, and may possibly be correlated inversely with lower resin content than was found in colony number 1.

4. Low resin content in colony number 2 is a disadvantage to the manufacturer to the extent of from 15 to 30%, while it is to the advantage of the collector in that total resin is larger in amount, while at the same time it takes less effort to collect a given amount of the crude drug.

5. Conversely, colony number 3 is relatively economically extracted, but it requires from three to five times as much effort in collection as colony number 2, since the rhizomes are much smaller, are less numerous, and dry out more completely. Of the three colonoies, number one is perhaps the most equitable to both parties, if prices are uniform for crude drug.

6. High resin content in plants of colony number 3 seems to be correlated with limited metabolism and low ash in the resin, and these are undoubtedly conditioned by lack of light and probable low transpiration. No atmometers were used in this work to determine actual transpiration.

7. Date of maximum resin content for autumn collection of drug seems to be from October 1st to 10th in normal seasons. This agrees closely wtih unpublished data of F. A. Miller, who found an autumn and a spring maximum.

More extensive analyses covering several seasons and soils are desirable, and the bearing of drug plant breeding and soil analysis must also be thor-

oughly investigated before the relations of economical production and environment can be thoroughly understood and used to the best advantage by the collector or producer and the manufacturer.

Ann Arbor, Mich.

February, 1919.

PERIODICITY OF ELONGATION AND CELL DIVISION.

RAY C. FRIESNER.

([1] Preliminary Note.)

For this work seedlings of *Cucurbita Pepo, Lupinus albus, Pisum sativum, Zea everta, Vicia faba and Allium Cepa;* and germinating bulbs of *Allium Cepa, A. canadense* and *A. cernuum* were used. Elongation of the roots was measured by the Barnes horizontal miscroscope fitted with a micrometer scale. For cell division root tips were cut every two hours, killed and fixed in medium chromo-acetic acid, sectioned and stained in Delafield's haematoxylin. The number of cells undergoing division was then determined by actual count, and the results reduced to a common area of one square millimeter. All work was done in a dark room at constant temperatures.

Elongation, when considered in shorter intervals of time (one hour), is found to proceed in a wave-like fashion. These waves are usually of short duration (two or three hours from crest to crest) and show apparently little uniformity among different individuals in regard to the exact time of high and low points. But in almost all cases these smaller waves are found to be parts of more extensive waves, which appear more clearly when the curves are drawn for longer intervals of time (two hours). Such curves for the elongation of roots grown from bulbs of *Allium Cepa* fall into two classes. The larger part, about 75%, exhibit three waves of elongation in 24 hours. The remaining 25% shows two waves. Those from seed of *Allium Cepa* again fall into two classes, which are fairly equally divided, viz., three waves and four waves. An early morning (5 to 9 a. m.) high point is common to all these curves, with the exception of a few of those which show only two waves, the high point being delayed in these latter until near noon. Likewise a low point is found at 9 or 11 p. m. in almost all the curves. The other waves appear with somewhat less uniformity. High points at noon and near sunset and low points in the forenoon and afternoon appear in a large number of curves.

In the curves for cell division the minor fluctuations are not nearly so prominent, and the waves are much more uniform and regular. Curves for cell division in roots from both bulbs and seeds of *Allium Cepa* show clearly and definitely three waves in the 24-hour period. Further, the curves are almost identical in regard to the time of high and low points. This greater degree of uniformity and regularity as compared to elongation curves may be explained by the facts, (1) that observations were made only every two hours;

[1]This work is being done at the University of Michigan under the direction of Professor F. C. Newcombe. Complete results will soon be ready for publication.

(2) that we are here dealing not with the curve for a single individual, but rather the average of a number of individuals; (3) that cell division when once initiated requires some little time for completion, and we are here dealing also, to more or less extent, with cumulative results, and hence would not expect to find so many minor variations.

The relation between cell division and elongation is not so clearly shown when we compare any individual elongation with that of cell division, and in the light of what has just been said we would hardly expect anything else. But when all the curves are considered we find that the average time for the high points of the one come near the average time of the low points of the other.

This same rhythmic or wave-like nature of elongation and cell division is found in all the species studied. In some the waves are of longer duration and hence fewer occur in a 24-hour period; in others they are shorter, giving more. In *Zea everta* the minor fluctuations are more numerous, but underlying them are the larger general waves.

The outstanding conclusion to be drawn from the data at hand is that there are definite waves or rhythms in both elongation and cell division of these plants, even in constant environmental conditions, but there is no uniformity in the various curves in regard to the "clock" time of their high and low points.

ON THE OCCURRENCE OF ROOT-HAIRS ON OLD ROOTS OF HELIANTHUS RIGIDUS.

E. E. WATSON.

The root-hair, as an organ of absorption, covers typically not more than one or two centimeters of the root, a few millimeters above the root tip. During the progress of an investigation of the subterranean organs of certain Helianthi, I observed that the roots of several species of this genus produced hairs on much older portions of the root. Conspicuous among these is *H. rigidus*.

The general habit of this plant resembles that of *H. occidentalis*. The parent plant sends out rhizomes in all directions from the base of the stem. These attain a length of one to three decimeters. They do not grow out horizontally, as do most rhizomes, but grow down at an angle of 45°, and then curve upward until they reach very nearly to the surface of the soil, there terminating in a rather large loosely constructed bud. The rhizome does not bear roots except from a point about 5 cm. from the terminal bud. Here four or five simple roots are produced, which grow straight down, and attain a length of one or two decimeters. These roots are unusually rough and uneven in appearance.

Examination of transverse sections of these roots reveals the presence of typical root-hairs thruout their entire length. The hairs present two peculiarities; first, they are unusually long, many being found that measured .5 mm. or more; second, a very considerable proportion of them are branched. No septate hairs were found, and the branching is dichotomous.

Leavitt, in the proceedings of the Boston Society of Natural History, Vol. 31, describes two methods of root-hair origin. It is to be noted that the hairs from the older portions of the root are produced according to the second method; that is, they arise from a small wedge-shaped cell of the epidermis, which has been formed by an unequal division of an epidermal cell, and the formation of an oblique cell wall.

University of Michigan.

A COLLECTION OF SPHAGNUM FROM THE DOUGLAS LAKE REGION, CHEBOYGAN COUNTY, MICHIGAN.

W. E. PRAEGER.

The following Sphagna were collected during the summer of 1918 at Douglas Lake, Cheboygan County, Michigan, at the request of Dr. Geo. E. Nichols, advisor to the Red Cross on Sphagnum for surgical dressings. The specimens were finally determined by Dr. Albert Le Roy Andrews.

The chief purpose of the collection ceased with the armistice. Only one of my samples (number 24, *Sphagnum magellanicum*) was first grade dressing material; this was from one of the small bogs and not in great quantity. One other (number 15, *S. palustre*) was fair but also existed in small quantities. Two others (numbers 9 and 10, both *S. magellanicum*) were poor but might be used; the rest were worthless. The collection however will be a help to those who in future may survey the Bryophytes of the Douglas Lake Region, and in this hope I record the list of species with localities. Samples of all numbers have been deposited in the Cryptogamic Herbarium of the University of Michigan.

Sphagnum Girgensohnii Russow.
    Number 1, The Gorge.

S. Girgensohnii forma
    Number 17, Hemlock Island.

S. squarrosum Crome.
    Numbers 2 and 3, The Gorge. Sporophytes present.

S. cuspidatum Ehrh.
    Numbers 4 and 5, Mud Lake Bog. Sporophytes present.
    Numbers 23 and 24, Hog Back Bog.

S. capillaceum (Weiss) Schrank.
    Number 16, Hemlock Island.
    Number 22, Hog Back Bog.

S. capillaceum-tenellum (Schimp.) A. L. Andrews.
    Number 6, Reese's Bog.
    Number 19, Bryant's Bog.

S. fuscum (Schimp.) H. Klingger.
    Number 7, Reese's Bog.

S. Wulfianum Girg.
    Number 8, Reese's Bog.
    Number 26, Bridge Bog.

S. magellanicum Brid.

Number 9, Reese's Bogk.

Numbers 10 and 11, Gleason's Bog.

Numbers 18 and 21, Bryant's Bog.

Number 24, Hog Back Bog.

Number 25, Bridge Bog.

S. recurvum Beauv.

Number 12, Gleason's Bog.

Numbers 19, 20 and 21, Bryant's Bog.

S. recurvum tenue H. Glingger.

Number 12, Gleason's Bog.

S. Dusenii C. Jens.

Numbers 13 and 14, Gleason's Bog.

S. palustre L.

Number 15, Vincent Lake.

Kalamazoo College, Kalamazoo, Mich.

DISTRIBUTION OF THE ORCHIDACEAE IN MICHIGAN.*

H. T. DARLINGTON.

The Orchidaceae, unlike many other plant families, contains no adventive species within the state, so far as we know; again, the species are, generally speaking, uncommon, so that the family lends itself more readily to a rather definite treatment so far as the distribution of species is concerned, than most other families. It is known to be quite cosmopolitan, so that where marked contrasts in distribution are observed, they are due to quite natural causes, except in those sections of the state where cultivation or drainage has rendered certain species less plentiful.

Following the nomenclature of the Illustrated Flora, we have in the state twenty-four genera of the Orchidaceæ, including nearly fifty species. A study of the distribution of these species has been based on an examination of many herbarium specimens, as well as on the records obtained from reliable lists of plants. Points of collection have been located on small maps of the state showing the counties and principal rivers. In general, the county has been made the unit of location. The writer realizes that distribution records of this kind can never be complete. The principle of priority has been followed as nearly as possible when a plant species has been reported more than once from any county. As many plants have been examined as possible. When this could not be done, records were from men whose ability as collectors was known.

The one point which perhaps stands out most clearly from an examination of the distribution maps is the sparse orchid flora of the Jack Pine region. In the Southern Peninsula, this region extends roughly from a line drawn east and west through about the southernmost point of Saginaw Bay north to a line drawn from Thunder Bay west to the head of Grand Traverse Bay. Apparently the greater number of species are found south of this region. The evidence for this may be partly due to the fact that the northern counties have not been so carefully examined, yet it seems clear that our orchid flora is richer in the deciduous than in the coniferous areas.

There are probably three or four species in the state belonging to this family which have not yet been reported. On the other hand, it is very doubtful whether the Crane-fly Orchis, *Tipularia unifolia* (Muhl.) B. S. P., reported for this state, has ever been found here. There is no record of its having been collected here during the last sixty years, so far as we have been able to determine. Dr. Dennis Cooley, whose botanical work in this state was done between

*This article was written at the suggestion of Dr. E. A. Bessey, whose encouragement at all times has been appreciated.

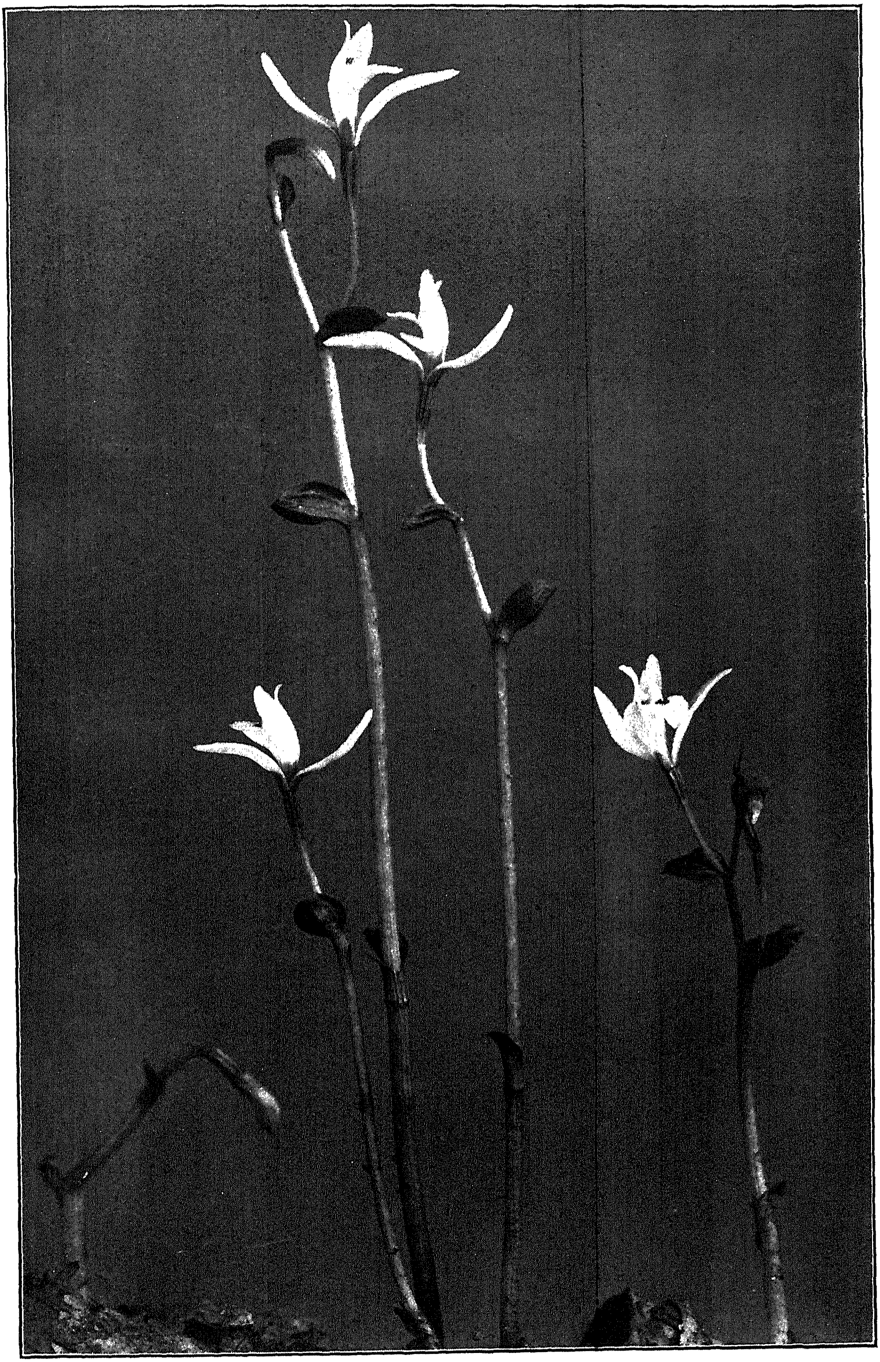
1827 and 1860, reported this plant, but it seems probable that he was mistaken in his identification. A. A. Wright, in a list of the plants of Lorain county, Ohio, published in 1889, notes Tipularia for that section. One specimen of this plant has also been reported from Clifty Falls, Indiana, by Prof. A. H. Young, so that there is a bare possibility of the plant being found as far north as southern Michigan. However, reports from the New York Botanical Garden, the Gray Herbarium and the Field Columbian Museum, Chicago, all indicate that no verified specimens have been found this far north.

Possibly the rarest of the species known to occur in this state is the Nodding Pogonia, *Triphora trianthophora*.. A few specimens of this orchid have been collected in the Southern Peninsula. Gray's Manual reports the habitat of this plant as "woods." Other rare species are *Liparis liliifolia*, *Cypripedium arietinum*, *Orchis rotundifolia*, *Isotria verticillata*, *Peramium tesselatum*, *Malaxis unifolia* and *Malaxis monophylla*.

Certain of our orchid species have a well marked northern range in this state. Among these may be mentioned *Cytherea bulbosa*, *Lysiella obtusata* and three species of Ophrys. Cytherea is found in the Upper Peninsula and in the northern part of the Lower Peninsula. It was collected in the Upper Peninsula before 1850 by Wm. A. Burt, inventor of the Burt solar compass. Our record for its most southerly limit is Isabella county, where it was collected by Irwin F. Smith. From this point north it has been found at several localities, including such isolated situations as Thunder Bay Island, Mackinac Island and Isle Royale. This pretty little pink and yellow orchid, which resembles somewhat a small Ladies'-slipper, is one of our distinctly boreal species, and probably further investigations in the Upper Peninsula will prove it to be rather frequent.

As before indicated, there are certain species which have been found in territory near or adjacent to Michigan which have not been reported for the state. The northern Ladies'-slipper, *Cypripedium passerinum*, reported from Ontario on north, is likely to be found in the upper peninsula. *Piperia unalaschensis* is known to occur in Quebec, Ontario, and on westward, so that we should expect to find it in the Upper Peninsula. *Ibidium ovale* is reported as far north as Ohio and Illinois and should be sought for in the extreme southern part of the state.

In conclusion, it may be said that the orchid flora of the state, so far as known, comprises 70% of the total number of species known to occur within the northeastern United States and Canada.



ORCHIDACEAE (Orchid Family.)*

A. Lip a large oval inflated sac; perfect anthers 2.
  Stem leafy; lip not fissured; flower yellow, or white variegated with crimson.......................... 1. *Cypripedium.*
  Leaves only 2, basal; flowers pink.................. 2. *Fissipes acaulis.*

A. Lip not an inflated sac; perfect anther 1.
  Plants saprophytic, without green herbage; stems yellowish or purplish............................ 24. *Corallorrhiza.*
  Plants normally with green herbage.
    B. Flowers with a conspicuous spur at least 2 mm. long.
      Lip fringed, divided, or 3-parted; tall leafy-stemmed plants of moist situations........ 11. *Blephariglottis.*
      Lip not fringed, divided, or 3-parted.
        C. Flowers purplish or rose color; leaves basal; lip whitish
          Leaf solitary; flowers (1–1½ cm. long) in a tall raceme, rose colored...... 3. *Orchis rotundifolia.*
          Leaves 2, obovate; flowers (2–3 cm. long) purplish, in a raceme........ 4. *Galeorchis spectabilis*
        C. Flowers mostly greenish or greenish white.
          D. Leaves radical, 1 or 2.
            Basa leaf 1; ovary strongly curved; spur about equal to the lip.................. 10. *Lysiella obtusata.*
            Basal leaves 2; ovary straight; spur 2 or 3 times longer than the lip.................. 9. *Lysias.*
          D. Leaves cauline.
            Spur long-clavate, strongly curved; stem with 1 basal leaf..................... 7. *Gymnadeniopsis clavellata.*
            Spur not long-clavate, not strongly curved; stems leafy, tall.
              Lip 3-toothed at the apex; floral bracts long and conspicuous................ 6. *Coeloglossum bracteatum.*

*This key, adapted to suit Michigan conditions, is based in part on that of the Illustrated Flora by Britton and Brown, and in part on Gray's Manual, 7th edition. The writer is responsible for the general arrangement, which is believed will simplify for beginners the identification of our orchid flora.

Lip hastate or lanceolate.
Lip hastate, with a tubercle at the base; uppermost leaves narrowly lanceolate .... 5. *Perularia flava.*
Lip lanceolate, entire; lateral sepals free .... 8. *Limnorchis.*

B. Flowers without a conspicuous spur.
Flowers in slender, more or less twisted spikes, whitish or yellowish-white; leaves 2–5, usually linear or linear-lanceolate .... 17. *Ibidium.*
Flowers not in twisted spikes; inflorescence various; leaves broader, or when linear only 1.
C. Perianth at least 15 mm. across; flowers more or less pink, red or purplish (only the sepals purple in *Isotria*).
D. A solitary basal linear or linear-lanceolate leaf present, visible during or after anthesis.
Flower single, large (2.5–5 cm. long), rose-purple .... 15. *Arethusa bulbosa.*
Flowers several, racemose; purplish pink, 2–3 cm. long .... 16. *Limodorum tuberosum.*

D. Leaves usually several (1 in *Cytherea*); not linear.
Leaf 1, round-ovate; flower solitary; lip saccate .... 22. *Cytherea bulbosa.*
One or more cauline leaves present.
Flowers several, pale purple, sometimes white, in the axils of ovate, sessile leaves 14. *Triphora trianthophora.*

Flowers usually solitary, terminal, more or less nodding.
Leaves 1–3, ovate-lanceolate; flowers pale rose color .... 12. *Pogonia ophioglossoides.*

Leaves in a whorl of 5 near the summit of stem; sepals and petals linear. 13. *Isotria verticillata.*

C. Perianth less than 15 mm. across; flowers greenish-white to whitish, or dull yellow.
Leaves several, basal, often veined with white; flowers in bracted spikes . 19. *Peramium.*
Leaves only 1 or 2 (visible after anthesis in *Aplectrum*).
Flowers dull yellow in a short raceme; plant with globular corms connected by a slender root-stock.... 23. *Aplectrum hyemale.*
Flowers greenish-white to whitish; petals filiform or linear.
Leaf solitary, sheathing the stem.. 20. *Malaxis.*
Leaves 2.
Leaves basal, lanecolate to ovate; lip 5–12 mm. long; plants with solid bulbs..........., 21. *Liparis.*
Leaves in a pair near the middle of the stem; flowers small (less than 4 mm. long); no bulbs; roots stringy...,......... 18. *Ophrys.*

1. CYPRIPEDIUM L. Ladies' Slipper. Moccasin Flower.

The three sepals separate; stem 1-flowered; flowers small (1.5–2 cm. long)................................ 1. *C. arietinum.*
The three sepals more or less united.
Sepals and petals shorter than the lip, which is crimson-magenta in front.............................. 2. *C. reginae.*
Sepals and petals equaling or longer than the lip.
Lip white, small (18–20 mm. long).................. 3. *C. candidum.*
Lip yellow, large.
Lip 2–3 cm. long, golden-yellow; plant of boggy places. 4. *C. parviflorum.*
Lip 3.5–5 cm. long, light yellow; mostly in woods.... 4a. *C. parviflorum var. pubescens.*

1. **Cypripedium arietinum** R. Br. (ram's head).
Ram's Head Ladies'-slipper.
Rare in the Lower Peninsula. Damp woods and swamps. May, June.
Lip "prolonged at the apex into a long, blunt spur, somewhat distorted at the upper end, which resembles a ram's head, whence the specific name".

Specimens examined:—Isabella Co. (C. A. Davis, June, 1893); Antrim Co. (H. T. Blodgett, May, 1908); Thunder Bay Island (C. F. Wheeler, July, 1895); Gratiot Co. Alma, (C. A. Davis, May, 1895); Lambton Co., Ontario (C. K. Dodge, 1906), "plentiful".

Reported from:—Isle Royale (Dr. A. B. Lyons); Washtenaw Co. (W. H. Lewis); Emmet Co. (Fallass and Swift), rich woods.

2. **Cypripedium reginae** Walt. (queenly).

Cypripedium hirsutum Mill.

Cypripedium spectabile Salisb.

Showy Ladies'-slipper.

Swamps and wet woods frequent throughout, but becoming scarce. June—Sept. This is the largest and most beautiful species. It transplants well and will thrive in shady, rich soil. It should be seen in more flower gardens.

Specimens examined:—Muskegon Co. (C. D. McLouth, July, 1899); Gratiot Co. (C. A. Davis, June, 1891); Ingham Co. (J. L. Cole, June, 1895); Ionia Co. (C. F. Wheeler, June, 1890); Keweenaw Co. (O. A. Farwell, 1886); Macomb Co. (Dr. D. Cooley, 1835); Marquette Co. (B. Barlow, June, 1901); Cheboygan Co. (F. C. Gates, July, 1911), No. 89; Cass Co. (H. S. Pepoon, Aug., 1905), No. 359; Alpena Co. (E. A. Bessey, 1918); St. Clair Co. (C. K. Dodge, July, 1892); (Sugarloaf Lake, A. B. Burgess, June, 1903).

Reported from:—Oakland Co. (C. Billington); Washtenaw Co. (I. W. Stacey), "frequent"; Kent Co. (Emma Cole); Calhoun Co. (C. E. Barr); Jackson Co. (S. H. Camp); Kalamazoo Co. (Tuthill); Genesee Co. (Wheeler and Smith); Isle Royale (W. P. Holt, 1908); Mackinac Island (C. K. Dodge); Dickinson Co. (C. J. Hill, 1884); Tuscola Co. (C. K. Dodge); Presque Isle Co. (C. K. Dodge), "abundant in spots"; Emmet Co. (Fallass and Swift).

3. **Cypripedium candidum** Willd. (pure white).

Small White Ladies'-slipper.

Bogs and tamarack swamps. May, June. Reported almost exclusively in the four lower tiers of counties of the Lower Peninsula

Specimens examined:—Kent Co. (H. C. Skeels, June, 1893); Kalamazoo Co. (R. M. Gibbs, May, 1877); Livingston Co. (C. F. Wheeler, June, 1890); Jackson Co. (S. H. Camp, June, 1900); Macomb Co. (Dr. D. Cooley, June, 1843); delta islands of St. Clair River (C. K. Dodge, 1896), "plentiful".

Reported from:—Cass Co. (H. S. Pepoon), "bogs"; Orion and Lakeville, Oakland Co. (C. Billington), "rare"; Genesee and Ionia counties (Wheeler and Smith); Washtenaw Co. (Winchell); Keweenaw Co. (O. A. Farwell); Calhoun Co. (C. C. McDermid), "rare".

4. **Cypripedium parviflorum** Salisb. (small-flowered).

Yellow Ladies'-slipper.

Frequent in the southern part of the Lower Peninsula; apparently rarer farther north. May-June.

This rather slender species prefers very wet swamps, where it grows in clumps. Corolla smaller and brighter yellow than the following. The specific name is unfortunate.

Specimens examined:—Gratiot Co. (C. A. Davis, June, 1888); Cheboygan Co. (F. C. Gates, July, 1911); Ingham Co. (F. L. Sleeper, June, 1867); Kent Co. (L. J. Cole, May, 1895); Kalamazoo Co. (F. A. Tuthill); Emmet Co. (F. C. Gates, 1917); Jackson Co. (S. H. and D. R. Camp, May, 1898); St. Clair, (C. K. Dodge, May, 1894).

Reported from:—Calhoun Co. (C. E. Barr); Macomb and Washtenaw counties (I. W. Stacey); Isle Royale (W. P. Holt); "from Bay Co. to St. Ignace, and on Mackinac Island," (C. K. Dodge); Oakland Co. (C. Billington); Marquette Co. (C. K. Dodge, 1918).

4a. **Cypripedium parviflorum** var. **pubescens** (Willd.) Knight. (downy).

Downy Yellow Ladies'-slipper.

The distribution of this plant throughout the state is practically identical with Cypripedium parviflorum. May—June. Mostly found in woods and thickets. The plant is larger in every way than *C. parviflorum* and the flowers are light yellow. The roots and rootstocks of this and the foregoing are medicinal. The glandular hairs are irritant to the skin of some people.

Specimens examined:—Marquette Co. (B. Barlow, June, 1901); Mackinac Island (G. H. Hicks, June, 1889); Oscoda Co. June, 1888; Gratiot Co. (C. A. Davis, June, 1888); Ingham Co. (F. L. Sleeper, June, 1867); St. Clair Co. (C. K. Dodge, 1893).

Reported from:—Muskegon Co. (C. D. McLouth); Calhoun Co. (C. E. Barr); Oakland Co. (C. Billington); Washtenaw Co. (I. W. Stacey); Kent Co. (Emma Cole); Isle Royale (W. P. Holt, 1908); Cheboygan Co. (F. C. Gates); Tuscola Co. (C. K. Dodge); "from Bay Co. to St. Ignace and on Machinac Island" (C. K. Dodge).

The Northern Ladies'-slipper (*Cypripedium passer num* Richards) reported from Ontario and on north, should be sought for in the Upper Peninsula. Stem 1.5–2.5 dm. high, villous pubescent; sepals and petals shorter than the lip; lip 10–15 mm. long, pale magenta, spotted with deeper magenta at the base within.

2. FISSIPES Small.

Fissipes acaulis (Ait.) Small. (stemless).

Cypripedium acaule Ait.

Moccasin Flower. Stemless Ladies'-slipper.

Woods and sphagnous swamps, frequent throughout. "In shady, sandy ground along the Huron shore, but seldom abundant", Dodge. May-June.

There seems to be some evidence of there being two forms of this species, one thriving in wet ground, and the other in more or less dry situations.

Specimens examined:—Clare Co. (C. A. Davis, May, 1893); Van Buren Co. (H. S. Pepoon, Aug., 1905) No. 316; Ingham Co. (L. J. Cole, May, 1895); Marquette Co. (B. Barlow, May, 1901); Macomb Co. (Dr. D. Cooley, May, 1842); Grand Traverse Co., June, 1888; Antrim Co. (H: T. Blodgett, May, 1908); Keweenaw Co. (O. A. Farwell, July, 1887); Cheboygan Co. (J. H. Ehlers, 1917) No. 311; Alger Co. (J. M. Coulter, July, 1892); Mason Co. (R. W. Chaney, Sept., 1910); Lake Harbor, (L. M. Umbach); Jackson Co. (S. H. Camp, May, 1898); Chippewa Co. Iosco and St. Clair, Schoolcraft Co. (W. T. S. Carvell, June, 1916); Gogebic Co. (H. T. Darlington, 1919); Ottawa Co. (E. A. Bessey).

Reported from:—Oakland and Washtenaw counties (I. W. Stacey); Kent Co. (Emma Cole); Jackson Co. (S. H. Camp); Charity Island (C. K. Dodge); Calhoun Co. (C. C. McDermid); Tuscola Co. (C. K. Dodge); Emmet Co. (Fallas and Swift).

3. **ORCHIS** [Tourn.] L.

Orchis rotundifolia Pursh. (round-leaved).

Small Round-leaved Orchis.

Rare. Probably commoner in Upper Peninsula. Damp woods. June—July.

Specimens examined:—Marquette Co. (T. M. Danger, June, 1891); near Petoskey (J. R. Stone, June 1893).

Reported from:—Lake Fume (E. J. Hill); Benzie Co. (E. J. Parker); Isle Royale, (W. P. Holt, 1908); Dickinson Co. (E. J. Hill, 1884); Emmet Co., near Harbor Springs (Fallass and Swift).

4. **GALEORCHIS** Rydb.

Galeorchis spectabilis (L.) Rydb. (showy).

Orchis spectabilis L.

Showy Orchis. Purple Orchis.

Rich woods, infrequent. Found mostly in the southern half of the Lower Peninsula. May—June.

Specimens examined:—Van Buren Co. (H. S. Pepoon, June, 1906), "rare"; Ingham Co. (L. J. Cole, May, 1895); Gratiot Co. (C. A. Davis, May, 1891); Alpena Co. (E. A. Bessey, July, 1918); St. Clair Co. (C. K. Dodge, May, 1892).

Reported from:—Oakland Co. (W. A. Brotherton); Kent Co. (Emma Cole), "infrequent"; Calhoun Co. (C. E. Barr); Jackson Co. (S. H. Camp); Macomb Co. (C. Billington); Marquette Co. (C. K. Dodge, 1918).

5. **PERULARIA** Lindl.

Perularia flava (L.) Farwell. (yellow).

Habenaria flava (L.) Gray.

Habenaria virescens Spreng.

Tubercled Orchis.

Moist places, occasional or frequent. Apparently commoner south. June—July.

Specimens examined:—Macomb Co. (Dr. D. Cooley, June, 1845); Gratiot Co. (C. A. Davis, July, 1883); Muskegon Co. (C. D. McLouth, June, 1899); Kent Co. (V. E. Mulliken, June, 1895), "infrequent"; St. Clair Co. (C. K. Dodge, July, 1892).

Reported from:—Detroit (O. A. Farwell, "rare"; Calhoun Co. (C. E. Barr); Jackson Co. (S. H. Camp); Washtenaw Co. (Wheeler and Smith); Bay Co. (G. M. Bradford); Bois Blanc Island (C. K. Dodge); Alpena to St. Ignace (C. K. Dodge), "frequent"; Oakland Co. (C. Billington); Marquette Co. (C. K. Dodge, 1918).

6. COELOGLOSSUM Hartm.

Coeloglossum bracteatum (Willd.) Parl. (having bracts).

Habenaria bracteata (Willd.) R. Br.

Long-bracted Orchis.

Woods and thickets throughout, occasional. Commoner north. May—Aug.

Specimens examined:—Gratiot Co. (C. A. Davis, May, 1888); Alger Co. (C. F. Wheeler, Aug., 1900), No. 82; Keweenaw Pt. (F. E. Wood, June, 1883); Macomb Co. (Dr. D. Cooley, 1843); Ionia Co. (C. F. Wheeler, June, 1890); Cass Co. (H. S. Pepoon, Aug., 1905), No. 422 "very rare"; Marquette Co. (B. Barlow, May, 1901); Benzie Co. (D. A. Pelton, June, 1888); Shiawassee Co. (G. H. Hicks, June, 1889); St. Clair Co. (C. K. Dodge); Gogebic Co. (H. T. Darlington, 1919).

Reported from:—Oakland and Washtenaw counties (I. W. Stacey), "frequent". Kent Co. (Emma Cole); Calhoun Co. (C. E. Barr); Jackson Co. (S. H. Camp); Emmet Kalamazoo and Genesee counties (Beal's Cat., 1904); Lansing, (L. H. Bailey); Isle Royale (W. S. Cooper); Charity Islands (C. K. Dodge); "in rich woods from Alpena to St. Ignace and on Mackinac Island", (C. K. Dodge.)

7. GYMNADENIOPSIS Rydb.

Gymnadeniopsis clavellata (Michx.) Rydb. (shaped like a little club).

Habenaria clavellata (Michx.) Spreng.

Small Green Wood Orchis.

Occasional throughout in bogs and moist woods. Usually rare locally. July—Aug.

Specimens examined:—Muskegon Co. (C. D. McLouth, July, 1899); Keweenaw Co. (O. A. Farwell, Sept., 1888); Gratiot Co. (C. A. Davis, 1888); Van Buren Co. (H. S. Pepoon, July, 1904), No. 104, "very rare"; Marquette Co. (B. Barlow, July, 1901); Alcona Co. (H. T. Darlington, July, 1918); Mason Co. (R. W. Chaney, Aug., 1910); Berrien Co. (J. M. Coulter, July, 1891); St. Clair Co. (C. K. Dodge); Schoolcraft Co. (C. A. Davis); Houghton Co. (C. K. Dodge); Gogebic Co. (E. A. Bessey, 1919).

Reported from:—Kent Co. (Emma Cole); Washtenaw Co. (Miss Allmendinger); Lenawee Co. (G. F. Comstock); Ionia and Crawford counties (G. H. Hicks); Isle

Royale (W. S. Cooper); Cheboygan Co. (F. C. Gates); Calhoun Co. (C. C. McDermid), "frequent"; Alger Co. (C. F. Wheeler); Emmet Co. (Fallass and Swift); Oakland Co. (C. Billington).

8. LIMNORCHIS Rydb.

Flowers greenish; base of the lip little dilated............. 1. *L. hyperborea.*
Flowers white, base of lip distinctly dilated; spike usually thicker and shorter.............................. 2. *L. dilatata.*

1. **Limnorchis hyperborea** (L.) Rydb. (northern).
Habenaria hyperborea (L.) R. Br.
Tall Leafy Green Orchis.
Bogs and wet woods, frequent throughout. June—Aug. Commoner north. A very variable species.

Specimens examined:—Manistee Co. (F. P. Daniels, July, 1900); Alger Co. (J. M. Coulter, July, 1892); Muskegon. (W. J. Beal, June, 1898); Charlevoix Co. (C. F. Wheeler, Sept., 1894); Iosco Co. (July, 1888); Macomb Co. (Dr. D. Cooley, Sept., 1849); Keweenaw Co. (O. A. Farwell, 1887); Ionia Co. (C. F. Wheeler, June, 1890); Marquette Co. (B. Barlow, June, 1901); Kalkaska Co. (June, 1888); Cheboygan Co. (F. C. Gates, July, 1911), No. 369; Gratiot Co. (C. A. Davis, Aug., 1891); Alpena Co. (H. T. Darlington, July, 1918); Mackinac Island (C. F. Millspaugh, July, 1898); Flint, (D. Clarke); Menominee Co. (J. H. Schuette, July, 1891); St. Clair Co. (C. K. Dodge, July, 1911); Gogebic Co. (H. T. Darlington, 1919).

Reported from:—Oakland and Washtenaw counties (I. W. Stacey), "frequent"; Kent Co. (Emma Cole), "infrequent"; Calhoun Co. (C. E. Barr); Jackson Co. (S. H. Camp); Isle Royale (W. P. Holt, 1908); Mackinac and St. Ignace to Alpena (C. K. Dodge); Alger Co. (C. F. Wheeler); Emmet Co. (Fallass and Swift).

2. **Limnorchis dilatata** (Pursh) Rydb.
Habenaria dilatata (Pursh) Gray.
Tall White Bog Orchis.
Bogs and wet woods, frequent throughout, though evidently less common than the preceding. June—August.

Specimens examined:—Alger Co. (C. F. Wheeler, Aug., 1900), No. 196; Macomb Co. (Dr. D. Cooley, 1838); Keweenaw Co. (O. A. Farwell, 1887); Ingham Co. (L. J. Cole, June, 1895); Marquette Co. (B. Barlow, July, 1901); Oakland Co. (G. H. Hicks, July, 1888); St. Joseph Co. (C. F. Wheeler, June, 1890); Alpena Co. (H. T. Darlington, July, 1918); Chippewa Co. (F. F. Forbes, June, 1914); Houghton Co., (C. K. Dodge).

Reported from:—Kent Co. (Emma Cole); Jackson Co. (S. H. Camp), "rare"; Isle Royale (W. P. Holt, 1908); Bois Blanc and Mackinac Islands (C. K. Dodge); Dickinson Co. (E. J. Hill, 1884); Calhoun Co. (C. C. McDermid); Emmet Co. (Fallass and Swift).

Closely related to Limnorchis is the genus Piperia Rydb. (*Habenaria* Wats.). *Piperia unalaschensis* (Spreng.) Rydb. is to be looked for in the Upper Peninsula.

Stem 3–5 dm. high; with radical leaves; bases of the lateral sepals adnate to the claw of the lip, which is less than 5 mm. long; flowers greenish, in a narrow spike.

9. LYSIAS Salisb.

Scape usually naked; lip 1 cm. long.	1. *L. hookeriana.*
Scape bracted: lip larger.	
Spur 1.5–2.5 cm. long	2. *L. orbiculata.*
Spur 3–4 cm. long	3. *L. macrophylla.*

1. **Lysias hookeriana** (A. Gray) Rydb.

Habenaria Hooderi Torr.

Hooker's Orchis.

Woods throughout, occasional. Less common than *L. orbiculata.* June—Sept.

Specimens examined:—Gratiot Co. (C. A. Davis, June, 1893); Ingham Co. (M. A. C. Herb., 1866); Marquette Co. (H. F. Monroe, July, 1880); Chippewa Co. (C. K. Dodge).

Reported from:—Dewey Lake (H. S. Pepoon); Kent Co. (Emma Cole), "infrequent"; Jackson Co. (S. H. Camp); Genesee Co. (Dr. D. Clark); Isle Royale (W. S. Cooper); Mackinac Island (C. K. Dodge); Dickinson Co. (E. J. Hill, 1884); Calhoun Co. (C. C. McDermid); Tuscola Co. (C. K. Dodge); Emmet Co. (Fallass and Swift).

2. **Lysias orbiculata** (Pursh) Rydb. (disk-shaped).

Habenaria orbiculata (Pursh) Torrey.

Round-leaved Orchis.

Woods, "Picea-Abies associations"—Gates. Throughout. July—August.

Specimens examined:—Marquette Co. (B. Barlow, July, 1901); Cheboygan Co. (F. C. Gates, July, 1911), No. 266; Traverse City (C. F. Wheeler, June, 1898); Oscoda Co. (H. T. Darlington, July, 1918); Mackinac Island (C. F. Millspaugh, July, 1898); Chippewa Co. (N. A. Wood, Aug., 1914).

Reported from:—Oakland Co. (C. Billington); Macomb and Washtenaw counties (I. W. Stacey), "frequent"; Kent Co. (Emma Cole); Calhoun Co. (C. E. Barr); Lansing (L. H. Bailey); Ionia and Genesee counties (Wheeler and Smith's Cat.); Isle Royale (W. P. Holt, 1908); Dickinson Co. (E. J. Hill, 1884); Calhoun Co. (McDermid's list); Lapeer and St. Clair counties (C. K. Dodge); Emmet Co. (Fallass and Swift).

3. **Lysias macrophylla** Goldie. (large-leaved).

Occurs along with the preceding species, of which some authors regard it as only a variety. Reported by C. K. Dodge in St. Clair Co. and Mackinac Island; Cheboygan Co. (Gleason and Gates); Bois Blanc Island (C. Billington).

10. LYSIELLA Rydb.

Lysiella obtusata (Pursh) Richards. (blunt at the apex).
Habenaria obtusata Richards.
Small Northern Bog Orchis.
Frequent in cedar bogs north. Rare south of Saginaw Bay.

Specimens examined:—Cheboygan Co. (F. C. Gates, July, 1911), No. 375; Marquette Co. (B. Barlow, July, 1901); Iosco Co. (Beal and Wheeler, July, 1888); Keweenaw Co. (O. A. Farwell, 1888); Pictured Rocks, Alger Co. (G. H. Hicks, July, 1888); Alcona Co. (H. T. Darlington, July, 1918); Isle Royale (J. H. Sandberg, June, 1889); St. Ignace, Mackinac Co. (T. E. Boyce, July, 1881); Mackinac Island (C. F. Millspaugh, July, 1898); Gogebic Co. (H. T. Darlington, Aug., 1919).

Reported from:—Schoolcraft, St. Clair and Mackinac Island (C. K. Dodge); Dickinson Co. (E. J. Hill, 1884); Emmet Co. (Fallass and Swift); Bois Blanc Island (C. Billington).

11. BLEPHARIGLOTTIS Raf. Fringed Orchis.

Lip fringed, not 3-parted or divided.
Flowers bright yellow .... 1. *B. ciliaris.*
Flowers white .... 2. *B. blephariglottis.*
Lip-parted, divisions toothed or fringed.
Flowers greenish or whitish, not purple.
Fringe of a few threads; segments narrow .... 3. *B. lacera.*
Fringe copious; segments broadly fan-shaped ...... 4. *B. leucophaea.*
Flowers purplish.................................. 5. *B. psychodes.*

1. **Blephariglottis ciliaris** (L.) Rydb. (fringed).
Habenaria ciliaris (L.) R. Br.
Yellow-fringed Orchis.
Rare. Reported only from the southern half of the Lower Peninsula. Sphagnous swamps. July—Aug.

Specimens examined:—Kent Co. (F. P. Daniels), "rare"; Macomb Co. (Dr. D. Cooley, Aug., 1843); Ingham Co. (L. J. Cole, 1888).

Reported from:—Cass Co. (H. S. Pepoon, Aug., 1904); Jackson Co. (S. H. Camp); Washtenaw Co. (Winchell's Cat.); Berrien Co. (I. N. Mitchell); St. Clair Co. (W. S. Cooper); Calhoun Co. (C. C. McDermid); Oakland Co. (C. Billington).

2. **Blephariglottis blephariglottis** (Willd.) Rydb. (having a fringed throat).
Habenaria blephariglottis (Willd.) Torr.
White-fringed Orchis.
Bogs and swamps, though occasionally plentiful at isolated spots, rare. July—Aug.

Specimens examined:—Charlevoix Co. (E. A. Bessey, Aug., 1912); Kent Co. (F. P. Daniels, July, 1899), "rare"; Antrim Co. (O. E. Close, 1894); Cheboygan Co. (F. C. Gates, July, 1911); Tuscola Co. (C. K. Dodge).

Reported from:—Jackson Co. (S. H. Camp).

3. **Blephariglottis lacera** (Michx.) Farwell. (torn).

Habenaria lacera R. Br.

Green-fringed Orchis.

Open swamps and wet woods, throughout. Infrequent. July—Aug.

Specimens examined:—Ingham Co. (L. J. Cole, July, 1895); Muskegon Co. (W. J. Beal, June, 1898); Lenawee Co. (W. J. Beal, 1866); Oakland Co. (Dr. D. Cooley, July, 1849); Cass Co. (H. S. Pepoon), "common"; St. Clair Co. (C. K. Dodge).

Reported from:—Wayne Co. (O. A. Farwell); Calhoun Co. (C. E. Barr); Jackson Co. (S. H. Camp); Genesee Co. (Dr. D. Clark); Macomb Co. (Dr. D. Cooley); Keweenaw Co. (O. A. Farwell); Washtenaw Co. (Winchell's Cat.); Manistee Co. (F. P. Daniels); Mackinac Island (C. K. Dodge), "open ground"; Marquette Co. (A. Dachnowski).

4. **Blephariglottis leucophaea** (Nutt.) Farwell. (white and red-brown).

Habenaria leucophaea (Nutt.) Gray.

Prairie White-fringed Orchis.

Moist, open meadows. Infrequent, but not as rare as *B. blephariglottis* in in Michigan. June—July. Dodge notes this species as "abundant on the delta islands of the St. Clair River".

Specimens examined:—Ingham Co. (W. A. Wells, May, 1867); Gratiot Co., (C. A. Davis, July, 1895); Livingston Co. (D. R. Short, 1866); Genesee Co. (Dr. Clarke).

Reported from:—Kent Co. (Mrs. M. B. Pieters), "rare"; Wayne Co. (O. A. Farwell); Oakland and Macomb counties (I. W. Stacey); Ionia Co. (Wheeler and Smith); Washtenaw Co. (Winchell's Cat.); Isle Royale (Foote); St. Clair Co. (C. K. Dodge); Calhoun Co. (C. C. McDermid); Tuscola Co. (C. K. Dodge); Emmet Co. (C. H. Swift).

5. **Blephariglottis psychodes** (L.) Rydb. (butterfly-like).

Habenaria psychodes (L.) Sw.

Smaller Purple-fringed Orchis.

Wet open meadows and swamps, frequent throughout; the commonest species. July—Aug.

Specimens examined:—Gratiot Co. (C. A. Davis, July, 1893); Cass Co. (H. S. Pepoon, Aug., 1904), No. 90; Shiawassee Co. (G. H. Hicks, July, 1889); Kent Co. (L. J. Cole, July, 1896); Lenawee Co. (W. J. Beal, 1866); Alpena Co. (E. A. Bessey, July, 1918); Newaygo Co. (H. T. Darlington, Aug., 1916, No. 1134); Clare Co. (E. A. Bessey, Aug., 1916, No. 698); Macomb Co. (Dr. D. Cooley, June, 1844); Cheboygan Co. (H. C. Beardslee, Aug., 1890); Delta Co. Escanaba (Henry H. Babcock); St. Clair Co. (C. K. Dodge); Alger Co. (N. A. Wood, July, 1916).

Reported from:—Calhoun Co. (C. E. Barr); Oakland Co. (I. W. Stacey); Jackson Co. (S. H. Camp); Isle Royale (W. P. Holt, 1908); Marquette Co. (A. Dachnowski); Tuscola Co. (C. A. Davis); Lapeer Co. (C. K. Dodge); Emmet Co. (Fallass and Swift); Wayne Co. (C. Billington).

This species is very variable. Two varieties found at Round Lake, Emmet Co. by Dr. Chas. H. Swift, are described in Annals of the Mo. Bot. Gard., Vol. IV, No. 1 (Feb., 1917) pp. 37–42. C.W. Fallass also reports $\times$ *Habenaria andrewsii* White in the vicinity of Round Lake.

Blephariglottis grandiflora (Bigel.) Rydb. has been reported from Jackson Co. by S. W. Camp, though we have examined no specimens. This species, which Dr. Britton says may be a large-flowered race of *B. psychodes*, is reported for Ontario and probably occurs in the state.

12. POGONIA Juss.

Pogonia ophioglossoides (L.) Ker. (like Ophioglossum, the Adder's Tongue).

Rose Pogonia.

Open sphagnous bogs and wet meadows, throughout. Frequent. June—July. This attractive species may easily be grown in bog gardens.

Specimens examined:—Ingham Co. (W. A. Wells, July, 1867); Oakland Co. (Dr. D. Cooley, July, 1850); Van Buren Co. (H. S. Pepoon, July, 1904), No. 203; Alpena Co. (H. T. Darlington, July, 1918); Muskegon (W. J. Beal); Isle Royale (Dr. A. E. Foote, 1868); Washtenaw Co. (V. M. Spalding, 1892); Cheboygan Co. (F. C. Gates, 1917); Mason Co. (R. W. Chaney, July, 1910); Chippewa Co. (N. A. Wood, Aug., 1914); St. Clair Co. (C. K. Dodge).

Reported from:—Kent Co. (Emma Cole); Calhoun Co. (C. E. Barr); Jackson Co. (S. H. Camp); Marquette Co. (A. Dachnowski); Emmet Co. (Fallass); Macomb Co. (I. W. Stacey).

13. ISOTRIA Raf.

Isotria verticillata (Willd.) Raf. (whorled).

Pogonia verticillata (Willd.) Nutt.

Whorled Pogonia.

Rare. Moist woods and tamarack swamps. May—June. Not reported north of Saginaw Bay. C. C. McDermid says this plant is frequent locally near Battle Creek.

Specimens examined:—Calhoun Co. (C. C. McDermid, June, 1909); Gratiot Co. (C. A. Davis, June, 1894); "Half Moon Lake" (C. F. Wheeler, 1894); Genesee Co. (Dr. D. Clark).

Reported from:—Kent Co. (Emma Cole's Cat.); Macomb Co. (Wheeler and Smith's Cat., 1881).

14. TRIPHORA Nutt.

Triphora trianthophora* (Sw.) Rydb. (bearing three flowers).
Pogonia trianthophora (Sw.) B. S. P.
Pogon a pendula Lindl.
Nodding Pogonia.
Very rare. "Rich woods, usually in leaf-mold". Aug.—Sept. Flowers pale purple, or occasionally white.

Specimens examined:—Clarksville, Ionia Co. (I. W. Stacey, Sept. 1901).

Reported from:—Magician Lake (H. S. Pepoon); Gratiot Co. (C. A. Davis).

15. ARETHUSA L.

Arethusa bulbosa. L. (bulbous).
Dragon's-Mouth.
Found throughout, though rare. Sometimes plentiful in isolated places. Bogs and sphagnous swamps. May—June.

Specimens examined:—Kent Co. (L. J. Cole, May, 1896), "infrequent"; Ingham Co. (F. L. Sleeper, 1867); Gratiot Co. (C. A. Davis, June, 1895); Kalkaska Co. (D. A. Pelton, June, 1888); St. Joseph Co. (C. F. Wheeler, June, 1890); Macomb Co. (Dr. D. Cooley, 1843); Washtenaw Co. (Douglas Houghton, 1838); Mackinac Island (J. B. Steere, 1870); Isle Royale, (Dr. S. E. Foote, 1868); Marquette Co. (T. M. Danger, June, 1891); Gogebic Co. (H. T. Darlington, Aug., 1919); Presque Isle Co., Chippewa Co., Alger Co. (C. K. Dodge); Schoolcraft Co., (W. S. Carvell, June, 1896).

Reported from:—Jackson Co. (S. H. Camp); Ionia Co. (Wheeler and Smith's Cat., 1891); Calhoun Co. (C. C. McDermid, "very rare"; near Cheboygan (C. K. Dodge); Emmet Co. (Fallass and Swift); Oakland Co. (W. A. Brotherton).

16. LIMODORUM L.

Limodorum tuberosum L. (producing tubers).
Calopogon pulchellus (Sw.) R. Br.
Grass-pink.
Bogs throughout. Frequent. June—July.

Specimens examined:—Cheboygan Co. (F. C. Gates, July, 1911), No. 38; Ingham Co. (L. J. Cole, June, 1895); Oakland Co. (G. H. Hicks, July, 1888); Gratiot Co. (C. A. Davis, July, 1895); Alpena Co. (C. F. Wheeler, July, 1895); Lenawee Co. (W. J. Beal, 1866); Macomb Co. (Dr. D. Coloey, June, 1843); Washtenaw Co. (M. W. Harrington, 1870); Jackson Co. (S. H. and D. K. Camp, June, 1897); St. Clair Co. (C. K. Dodge, June, 1896).

Reported from:—Cass Co. (H. S. Pepoon), "common" Kent Co. (Emma Cole); Calhoun Co. (C. E. Barr); Marquette Co. (A. Dachnowski); Tuscola Co. (C. K. Dodge); Otsego Co. (Dr. E. A. Bessey); Emmet Co. (Fallass and Swift).

This attractive species and the preceding are sold by dealers as bog garden plants.

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*__Nodding Pogonia__ *(Triphora trianthophora)* Michigan's rarest orchid. See page 239. Courtesy *of Edwin Hale Lincoln, photographer and publisher, Pittsfield, Mass.*

17. IBIDIUM Salisb. LADIES' TRESSES.

Flowers apparently in a single rank, secund; roots fasciculate; plant of dry places.................................. 1 *I. gracile.*
Flowers apparently in several ranks; plants of wet soil or moist woods.
 Flowering early (June—July); lip pale yellow; leaves about 1 cm. wide, oblong-lanceolate........................ 2. *I. plantigineum.*
 Normally flowering later (July—Oct.); leaves linear-lanceolate.
  Lip contracted below the apex; sepals and petals not distinctly spreading at apex........... 3. *I. strictum.*
  Lip oblong, not contracted below apex; sepals and petals distinctly spreading at tip.......... 4. *I. cernuum.*

1. 1. **Ibidium gracile** (Bigel.) House. (slender).
Spiranthes gracilis (Bigel.) Beck.
Gyrostachys simplex Kuntze.
Dry fields and open woods. Occasional throughout. July—Sept.
Specimens examined:—Gratiot Co. (C. A. Davis, Sept., 1894); St. Clair Co. (C. K. Dodge, Aug., 1892); Muskegon Co. (C. D. McLouth, Aug., 1901); Marquette Co. (B. Barlow, July, 1901); Macomb Co. (Dr. D. Cooley, 1848); Iron Co. (C. A. Davis, 1905); Gogebic Co. (E. A. Bessey, 1919).
Reported from:—Kent Co. (Emma Cole), "rare"; Jackson Co. (H. S. Camp); Kalamazoo Co. (Tuthill); Choboygan Co. (Kofoid and Beardslee); Calhoun Co. (C. C. McDermid); Emmet Co. (C. W. Swift); Lenawee Co. (C. Billington).

2. **Ibidium plantigineum** (Raf.) House. (plantain-like).
Spiranthes lucida (H. H. Eaton) Ames.
Spiranthes latifolia Torr.
Moist banks and woods. Apparently rare. June—July.
Specimens examined:—Ionia Co. (C. F. Wheeler), "in swamps, rare".
Reported from:—Calhoun Co. (C. E. Barr); Jackson Co. (H. S. Camp); Drummond's Island; Roscommon Co. (Beal's Cat., 1904).

3. **Ibidium strictum** (Rybd.) House. (stiff, upright).
Spiranthes romanzoffiana Cham. in part. (Gray's Man., 7th ed.).
Gyrostachys stricta Rydb.
Boggy soil, throughout. July—Sept.
Specimens examined:—Roscommon Co. (E. A. Bessey and H. T. Darlington, July, 1916), No. 426; Charlevoix Co. (C. F. Wheeler, Sept., 1894); Newaygo Co. (E. A. Bessey, Aug., 1916, No. 891); Mason Co. (Aug., 1895); Crawford Co. (G. H. Hicks,

Aug., 1888); St. Clair Co. (C. K. Dodge, Sept., 1892); Keweenaw Co. (O. A. Farwell, 1886); Isle Royale (Dr. A. E. Foote, 1868); Mackinac Island (T. S. Boyce, July, 1881); Iron Co. (C. A. Davis, Sept., 1905).

Reported from:—Kent Co. (Emma Cole); Jackson Co. (S. H. Camp); Leelanau Co. (E. J. Hill); Tuscola Co. (C. A. Davis); Cheboygan Co. (Miss Anna Arbuthnot); Emmet Co. (Fallass and Swift).

Most collectors in the state have referred this species to *S. romanzoffiana* Cham., an Alaskan plant.

4. **Ibidium cernuum** (L.) House. (nodding).

Spiranthes cernua (L.) Richard.

Wet meadows and swamps throught. Frequent. Aug.—Oct. Very variable.

Specimens examined:—Gratiot Co., Sept. 1892; Cass Co. (H. S. Pepoon, 1906), No. 865; Marquette Co. (B. Barlow, July, 1901, Ottawa Co.) (L. J. Cole, Aug., 1895); Macomb Co. (Dr. D. Cooley, Aug., 1848); Hillsdale Co. (H. B. Crosby); Ionia Co. (C. F. Wheeler, Sept., 1890); Ingham Co. (F. L. Sleeper, Sept., 1866); Washtenaw Co. (A. J. Pieters, 1892); Van Buren Co. (Judge A. W. De Selm, Aug., 1913); Mackinac Island (C. F. Millspaugh, July, 1898); Allegan Co. (U. A. Dohmen, Aug., 1898); Jackson Co. (S. H. and D. K. Camp, Aug., 1897); Houghton, St. Clair and Schoolcraft counties (C. K. Dodge).

Reported from:—Kent Co. (Emma Cole); Wayne Co. (O. A. Farwell); Calhoun Co. (C. E. Barr); Tuscola Co. (C. K. Dodge); Jackson Co. (S. H. Camp); Charity Is. (C. K. Dodge); Bois Blanc I. (C. K. Dodge); Emmet Co. (Fallass and Swift); Oakland Co. (C. Billington).

Ibidium ovale (Lindl.) House., known to occur in Ohio and Illinois, may be looked for in the southern part of the state. Stem 1–3 dm. high; leaves somewhat broader and spike narrower than *I. cernuum*, which it resembles.

18. OPHRYS [Tourn.] L. Twayblade.

Column less than 1 mm. in length; raceme glabrous........ 1. *O. cordata.*
Column 2–3 mm. long; rhachis pubescent or glandular-pubescent.
  Ovary glandular; lip not auriculate at base.............. 2. *O. convallarioides.*
  Ovary glabrous; lip auriculate at base.................. 3. *O. auriculata.*

1. **Ophrys cordata** L. (heart-shaped).

Listera cordata (L.) R. Br.

Damp mossy woods, cedar swamps, etc. Infrequent. June—Aug. Commoner in the Upper Peninsula.

Specimens examined:—Keweenaw Co. (O. A. Farwell, 1887); Marquette Co. (B. Barlow, June, 1901); Isle Royale (Douglas Houghton, 1840); Alger Co. (C. K. Dodge, 1916).

Reported from:—Roscommon Co. (G. H. Hicks); Cheboygan Co. (Beardsley and Kofoid); Dickinson Co. (E. J. Hill, 1884); Emmet Co. (C. W. Fallass).

2. **Ophrys convallarioides** (Sw.) W. F. Wight. (resembling Lily-of-the-Valley).
Listera convallarioides (Sw.) Torr.
Moist woods and cedar bogs. June—Aug. Upper Peninsula and northern part of the Lower Peninsula. Evidently more common than the preceding species.

Specimens examined:—Antrim Co. (B. T. Blodgett, July, 1892); Marquette Co. (B. Barlow, July, 1901); Benzie Co. (D. A. Pelton, June, 1888); Keweenaw Co. (O. A. Farwell, 1887); St. Joseph Co. (C. F. Wheeler, June, 1890); Isle Royale (Dr. A. E. Foote, 1868); Cheboygan Co., (H. C. Beardslee, July, 1890); Mackinac Island (C. F. Millspaugh, July, 1898); Schoolcraft Co. (C. K. Dodge).

Reported from:—Pictured Rocks, Alger Co. (G. H. Hicks); Grand Traverse Co. (Beal's Cat., 1904); Bear Lake (E. J. Hill); Emmet Co. (Fallass and Swift), "locally common".

3. **Ophrys auriculata** (Wiegand) House. (auricled).
Listera auriculata Wiegand.

Reported from:—Isle Royale by W. S. Cooper. Habitat, "bog forests". This is the only known locality in the state for this species. See Cat. of the Flora of Isle Royale, W. S. Cooper, Michigan Acad. Science, 1914. We have not seen his specimens.

19. **PERAMIUM** Salisb. RATTLESNAKE PLANTAIN.

Lip strongly saccate, with a short tip; spike cylindric, not one-sided; leaves 3–6.5 cm. long .... 1. *P. pubescens.*
Lip elongated; spike often one-sided (in a loose spiral in *P. tesselata*).
  Margin of the lip recurved or flaring; plants less than 3 dm. high.
    Another acuminate; tip of galea distinctly recurved; flowers in a loose spiral .... 2. *P. tesselatum.*
    Another blunt; spike distinctly 1-sided; leaves ovate, small (1.5–3 cm. long) .... 3. *P. ophioides.*
  Margin of the lip involute; plant large (3.5–4.5 dm. high) 4. *P. decipiens.*

1. **Peramium pubescens** (Willd.) MacM. (downy).
Epipactis pubescens (Willd.) A. A. Eaton.
Goodyera pubescens R. Br.
Downy Rattlesnake Plantain.
Throughout, frequent in the southern part of the state, evidently rarer north. Usually in dry woods. Aug.—Sept.

Specimens examined:—Cass Co. (H. S. Pepoon, Aug., 1904), No. 14; Ingham Co. (F. L. Sleeper, 1867); Macomb Co. (Dr. D. Cooley, Aug., 1848); Lenawee Co. (W.

J. Beal, 1866); Kalamazoo Co. (Douglas Houghton, 1838); Isle Royale (U. of M., Herb. 1868); Mackinac Island (C. F. Millspaugh, July, 1898); St. Clair Co. (C. K. Dodge).

Reported from:—Kent Co. (Emma Cole), "infrequent"; Jackson Co. (S. H. Camp); Calhoun Co. (C. C. McDermid); near St. Ignace (C. K. Dodge); Emmet Co. (C. Fallass); Oakland Co. (I. W. Stacey).

2. **Peramium tesselatum** (Lodd.) Heller. (checkered).

Epipactis tesselata (Lodd.) A. A. Eaton.

Dry coniferous woods, apparently not common. July—Aug. Mostly found north.

Only within the last fifteen years has attention been called to this species, which does not appear in Beal's Catalog of 1904.

Specimens examined:—Alger Co. (C. F. Wheeler, Aug., 1900), No. 84; Cheboygan Co. (W. J. Beal, Aug., 1909); Marquette Co. (B. Barlow, July, 1901).

Reported from:—Ypsilanti (O. A. Farwell); Isle Royale (W. S. Cooper); Mackinac Island (C. K. Dodge); Emmet Co. (Fallass and Swift), "dry woods".

3. **Peramium ophioides** (Fernald) Rydb. (snake-like).

Epipactis repens var. *ophioides* (Fernald) A. A. Eaton.

Lesser Rattlesnake Plantain.

Damp woods and cedar bogs, throughout. July—Aug. Apparently the most generally distributed of our species.

Specimens examined:—Iosco Co. (W. J. Beal, July, 1888); Keweenaw Co. (O. A. Farwell, Aug., 1888); St. Clair Co. (C. K. Dodge, 1894); Charlevoix Co. (C. F. Wheeler, June, 1900), No. 225; Alger Co. (C. F. Wheeler, Sept., 1900), No. 92; Cheboygan Co. (C. F. Wheeler, Aug., 1890); Manistee Co. (F. P. Daniels, Aug., 1900); Muskegon Co. (C. D. McLouth, Aug., 1899); Marquette Co. (B. Barlow, July, 1901); Emmet Co. (Mrs. K. Irwin, Aug., 1891); Van Buren Co. (L. H. Bailey); Isle Royale (Dr. A. E. Foote, 1868); Bois Blanc Island, Mackinac Co. (S. H. and D. R. Camp, Aug., 1896); Gogebic Co. (H. T. Darlington, Aug., 1919); Marquette Co. (C. K. Dodge).

Reported from:—Calhoun Co. (C. E. Barr); Kent Co. (Miss Coleman's Cat.); Roscommon Co. (Dr. D. Cooley); Gratiot Co. (C. A. Davis); Mason Co. (H. T. Blodgett, 1893); Oakland Co. (I. W. Stacey).

L. H. Bailey says this plant reaches its southern limit in Michigan in the neighborhood of South Haven. See Limits of Michigan Plants, Bot. Gaz., 1882.

4. **Peramium decipiens** (Hook.) Piper. (misleading).

Epipactis decipiens (Hook.) Ames.

Goodyera menziesii Lindl.

Menzie's Rattlesnake Plantain.

Dry woods. Common north. July—Aug.

Specimens examined:—Antrim Co. (O. E. Close, 1894); Manistee Co. (F. P. Daniels, Aug., 1900), "rare"; Keweenaw Co. (O. A. Farwell, Aug., 1888); Emmet Co.

(Mrs. K. Irwin, Aug., 1891); Bois Blanc Island (S. H. and D. R. Camp, Aug., 1894); Isle Royale (Dr. A. E. Foote, 1868); Cheboygan Co. (H. C. Beardslee, July, 1890), "very rare"; Marquette Co. (W. M. Canby, Aug., 1868); Mackinac (H. H. Babcock, Aug., 1869); Chippewa Co. (C. K. Dodge, 1914); Iron Co. (C. A. Davis, 1905).

Reported from:—Jackson Co. (S. H. Camp); Charlevoix, Leelanau and Benzie counties (E. J. Hill); Roscommon Co. (G. H. Hicks), "rare"; Mackinac Island (C. K. Dodge), "frequent".

20. MALAXIS Soland.

Lip pointed at base; length of pedicels barely equally the ovaries; whitish flowers in a slender raceme............ 1. *M. monophylla.*
Lip truncate at base; length of pedicels exceeding the ovaries; flowers greenish, in a short spreading raceme........... 2. *M. unifolia.*

1. **Malaxis monophylla** (L.) Sw. (one-leaved).
Microstylis monophyllos (L.) Lindl.
Achroanthes monophylla Greene.
White Adder's Mouth.
Occasional throughout. Usually rare locally. Damp woods. June—July.

Specimens examined:—Belleville, Eaton Co. (C. A. Davis, July, 1893); Shelby, Macomb Co. (Dr. D. Cooley, 1845); Washtenaw Co. (E. C. Allmendinger, 1860); Mackinac Co., (T. E. Royce, July, 1881).

Reported from:—Ionia and Genesee counties (Wheeler and Smith's Cat., 1881); Cheboygan Co. (Beardslee and Kofoid), "bogs rare"; Isle Royale (A. P. Holt, 1908); Emmet Co. (C. W. Fallass), "damp woods, very rare"; Oakland Co. and Bois Blanc Island (C. Billington).

2. **Malaxis unifolia** Michx. (with one leaf only).
Microstylis unifolia (Michx.) BSP.
Microstylis ophioglossoides Nutt.
Green Adder's Mouth.
Damp woods. Rare. July—Aug.

Specimens examined:—Gogebic Co. (E. A. Bessey, 1919).

Reported from:—Washtenaw Co. (Allmendinger's Cat.); Ionia and Lenawee counties (G. F. Comstock); Bay Co. (B. M. Bradford); Emmet Co. (C. W. Swift), "damp, mossy woods, very rare".

21. LIPARIS L. C. Richard. Twayblade.

Leaves elliptical or ovate; lip 10–12 mm. long, madder-purple, 1. *L. liliifolia.*
Leaves elliptic-lanceolate or narrower; lip 4–6 mm. long, yellowish-green.................................. 2. *L. loeselii.*

1. **Liparis ciliifolia** (L.) L. C. Richard. (lily-leaved).
Large Twayblade.

Apparently one of our rarest orchids. Moist woods and swamps. June—July.

Specimens examined:—Jackson Co. (Donna Camp, June, 1893), "tamarack swamp".

Reported from:—Oakland Co. (I. W. Stacey); near Battle Creek (C. C. McDermid); Isle Royale (W. P. Holt, 1908), "moist woods and along bog margins".

2. **Liparis loesellii** (L.) L. C. Richard. (Loesel's.)
Fen Orchis.

Frequent throughout. Usually in open, boggy ground. June—July.

Specimens examined:—Black River, Alcona Co. (E. A. Bessey, July, 1918); Muskegon Co. (C. D. McLouth, Aug., 1895); Marquette Co. (B. Barlow, July, 1901); Ingham Co. (L. J. Cole, June, 1895); Clinton Co., Aug., 1888; Macomb Co. (Dr. D. Cooley, June, 1848); Oscoda Co. (W. J. Beal and C. F. Wheeler, July, 1888); Keweenaw Co. (O. A. Farwell, July, 1888); Ionia Co. (C. F. Wheeler, June, 1890); Gratiot Co. (C. A. Davis, June, 1893); Cass Co. (Douglas Houghton, 1830); Washtenaw Co. (E. C. Allmendinger); Jackson Co. (S. H. Camp, June, 1899); Lapeer Co. (C. K. Dodge).

Reported from:—Wayne Co. (O. A. Farwell); Van Buren Co. (L. H. Bailey); Genesee Co. (Wheeler and Smith's Cat., 1881); Chippewa Co. (Porter); Isle Royale (W. P. Holt, 1908); Charity Islands and Mackinac Island (C. K. Dodge); Dickinson Co. (E. J. Hill); Calhoun Co. (C. C. McDermid); Tuscola Co. (C. K. Dodge); Emmet Co. (C. W. Fallass); Oakland Co. (C. Billington).

22. CYTHEREA Salisb.

Cytherea bulbosa (L.) House. (bulbous).
Calypso bulbosa (L.) Oakes.
Calypso borealis Salisb.
Calypso.

Occasional north, in damp mossy woods. May—June.

This pretty little orchid has not been recorded south of Saginaw Bay (1919).

Specimens examined:—Isabella Co. (C. A. Davis, May, 1892); "Lake Superior region" (Wm. A. Burt, 1849); Keweenaw Co. (O. A. Farwell, 1887); Marquette Co. (B. Barlow, May, 1901); Isle Royale (Dr. A. E. Foote, July, 1868); Mackinac (J. B. Steere, 1870); Schoolcraft Co. (W. S. Carvell, 1916); Benzie Co. (W. W. Weis, 1892).

Reported from:—Presque Isle Co. (N. H. Winchill's Cat., 1861); Higgin's Lake, Roscommon Co. (Dr. D. Cooley); Benzie Co. (E. J. Parker); Thunder Bay Island (C. K. Dodge); Emmet Co. (Fallass and Swift), "damp woods, very rare"; Bois Blanc Island (C. Billington).

23. APLECTRUM Nutt. PUTTY-ROOT.

Aplectrum hyemale (Muhl.) Torr. (lasting over the winter).

Frequent in the deciduous woods of the south half of the Lower Peninsula. Not recorded north of Saginaw Bay (1919). May—June.

Specimens examined:—Gratiot Co. (C. A. Davis, June, 1892); Macomb Co. (Dr. D. Cooley, May, 1844); Cass Co. (H. S. Pepoon, April, 1905), No. 656; Ingham and Van Buren counties (H. S. Pepoon, June, 1906), No. 698; Kent Co. (L. J. Cole, May 1895); Berrien Co. (G. L. Ames, 1868); St. Clair and Wayne counties (C. K. Dodge, 1897).

Reported from:—Jackson Co. (S. H. Camp); Washtenaw Co. (Miss E. C. Allmendinger); Wayne Co. (Gillman); Montcalm, Genesee and Ionia counties (Wheeler and Smith's Cat., 1881); Calhoun Co. (C. C. McDermid).

24. CORALLORRHIZA (Haller) Chatelain. CORAL-ROOT.

Lip with lateral lobes; mature ovaries medium-sized (8–15 mm. long).
- Lip white, not spotted; lateral lobes of lip small......... 1. *C. corallorrhiza.*
- Lip white, spotted, lateral lobes of lip large............. 2. *C. maculata.*

Lip not distinctly lobed laterally; the terminal portion may be denticulate; mature ovaries small (about 6 mm. long) or large (15–20 mm. long).
- Ovary about 6 mm. long; perianth about 4 mm. long.... 3. *C. odontorrhiza.*
- Ovary 15–20 mm. long; perianth large (16–18 mm. long), with conspicuous striations.......................... 4. *C. striata.*

1. **Corallorrhiza corallorrhiza** (L.) Karst.

Corallorrhiza trifida Chatelain.

Corallorrhiza innata R. Br.

Early Coral-root.

Frequent throughout, May—June. Usually in damp woods.

Specimens examined:—Van Buren Co. (H. S. Pepoon, June, 1903), No. 131; Manistee Co. (F. P. Daniels, June, 1900); Grand Traverse Co. (D. A. Pelton, June, 1888); Keweenaw Co. (C. A. Farwell); Gratiot Co. (C. A. Davis, June, 1894); St. Clair Co. (Douglas Houghton, 1838); Isle Royale (Dr. A. E. Foote, 1868); Cheboygan Co. (H. C. Beardslee, July, 1890); Sanilac and Alger counties, (C. K. Dodge).

Reported from:—Cass Co. (H. S. Pepoon); Oakland Co. (T. W. Stacey); Kent Co. (Emma Cole); Clinton, Roscommon and Benzie counties (Wheeler and Smith's Cat.); Bois Blanc Island, Mackinac Island and Thunder Bay Island (C. K. Dodge); Calhoun Co. (C. C. McDermid); Emmet Co. (Fallass and Swift), "damp mossy woods"; Marquette Co. (C. K. Dodge, 1918).

2. **Corallorrhiza maculata** Raf. (spotted).

Corallorrhiza multiflora Nutt.

Large Spotted Coral-root.

Woods throughout. Frequent. July—Sept.

Specimens examined:—Muskegon Co. (C. F. Wheeler, July, 1900), No. 309; Newaygo Co. (E. A. Bessey, Aug., 1916), No. 1018; Alpena Co. (C. F. Wheeler, July, 1895); Keweenaw Co. (O. A. Farwell, Aug., 1888); Van Buren Co. (H. S. Pepoon, Aug., 1903), No. 137; Kent Co. (L. J. Cole, July, 1896); Antrim Co. (O. E. Close, 1894); Cheboygan Co. (F. C. Gates, July, 1911), No. 202; Charlevoix Co. (C. F. Wheeler, Sept., 1900), No. 223; Macomb Co. (Dr. D. Cooley, Aug., 1848); Mackinac Island, (G. H. Hicks, June, 1889); Gratiot Co. (C. A. Davis, Sept., 1892); Kalamazoo Co. (Douglas Houghton, 1838); Isle Royale (U. of M., 1868); Marquette Co. (H. F. Munroe, July, 1880); Mason Co. (R. W. Chaney, July, 1910); St. Clair Co., (C. K. Dodge).

Reported from:—Calhoun Co. (C. E. Barr); Cass Co. (H. S. Pepoon); Jackson Co. (S. H. Camp); Ingham Co. (L. H. Bailey); Wayne Co. (O. A. Farwell); Charity Islands (C. K. Dodge); Emmet Co. (Fallass and Swift), "dry woods"; Oakland Co. (C. Billington).

S. Alexander reports *C. multiflora flavida* Peck from the vicinity of Birmingham, Michigan. See 12th Report Mich. Acad. Sci., 1910.

3. **Corallorrhiza odontorrhiza** (Willd.) Nutt. (having a toothed root).

Small Coral-root.

Woods. Infrequent. Evidently throughout. July—Sept.

Specimens examined:—Van Buren Co. (H. S. Pepoon, Aug., 1904); Benzie Co. (M. A. C. Herb, June, 1888); Mackinac Island (G. H. Hicks, June, 1889); Cass Co. (H. S. Pepoon, Aug., 1905), No. 377; St. Clair Co. (C. K. Dodge).

Reported from:—Oakland Co. (W. A. Brotherton); Calhoun Co. (C. E. Barr); Ionia Co. (Wheeler and Smith's Cat., 1881); Genesee and Oscoda counties (Beal and Wheeler's Cat., 1891); Marquette Co. (A. Dachnowski); Wayne Co. (C. Billington).

This slender species and the following large-flowered species are easily distinguished from the first two.

4. **Corallhorrhiza striata** Lindl.

Corallorrhiza macraei A. Gray Man. ed. 2.

Striped Coral-root.

Rich woods, occasional. June—July. Evidently common north.

Specimens examined:—Sanilac Co. (J. Beach, July, 1893); Keweenaw Co. (O. A. Farwell, Aug., 1888); Mackinac Island (G. H. Hicks, June, 1889); Oscoda Co. (D. A. Pelton, June, 1888); Marquette Co. (B. Barlow, July, 1901); Benzie Co. (D. A. Pelton, June, 1888); Emmet Co. (F. C. and M. T. Gates, 1917); Menominee Co. (J. H. Schuette, Aug., 1884); Thunder Bay Island (C. K. Dodge).

Reported from:—Calhoun Co. (C. E. Barr); St. Clair Co. (C. K. Dodge); Alpena to St. Ignace (C. K. Dodge), "rich shaded ground, common".

THE HEREDITY OF "ROGUE" TYPES IN GARDEN PEAS (*PISUM SATIVUM*).

WILBER BROTHERTON, JR.

DESCRIPTION OF MATERIAL.

Plantings of certain verieties of the garden pea, *Pisum sativum*, occasionally contain plants described as "wild" or "vetch-like," whose origin was long in doubt. These "rogues," as they are called, are characterized chiefly by a reduction in the width of the pods and of the foliar parts (leaf blades and stipules). In the case of the Gradus variety, for example, the foliage of the rogues is coarser in texture than that of typical plants, darker green, and smooth rather than wavy. In height the rogues, on the whole, make a taller and ranker growth. The increase in height may be due to an increase in number of the internodes as well as to an increase in their length. Associated with increased height is often a difference in flowering time, so that the rogues mature on the average later than does the typical form. The varieties in which rogues are found have large, wide pods that may or may not be slightly curved along the ventral suture. Seemingly correlated with the reduction in width of the foliar parts is a reduction in size of the pods and an increase in their curvature, so that rogue pods are often spoken of as "sickle-shaped." With a change in shape of pod comes a change from the sub-cuneiform seed of the varietal type to "drum-shaped" seeds in the rogue. (The seeds of the type are shown in Plate VII a; those of the rogue in Plate VII b). The rogue seeds are on the average slightly smaller in size than type seeds. Thus, in the variety "Gradus" the average weight of 178 seeds from three type plants was 0.309 grams, and that of 224 seeds from three rogue plants was 0.270 grams. However, it is the difference in shape which is most characteristic of the dry rogue seed. In the green state the seed of the rogue is bitter to taste, as compared with the sweet flavor of the type seed. In other characters, such as color and surface (whether wrinkled or smooth), the rogue seed is like the variety from which the rogue originated.

It should also be mentioned here that the rogues show a decrease in the size of the floral parts so that the petals are smaller than in the normal plant. In regard to hardiness and productiveness the rogues equal and sometimes surpass the type, although occasionally sterile rogues are met with. Plates VIII and IX show, respectively, herbarium specimens of the upper part of a mature type plant and a rogue plant.

INTERGRADING ROGUES.

On three occasions plants classified as type when developed to the 7th or 8th node, were later characteristic rogues at the upper nodes. Plants of

21st Mich. Acad. Sci. Rept., 1919.

this kind have been called intergrading Rabbit-Ear rogues, to distinguish them from the normal Rabbit-Ear rogue, which can be recognized as such at all stages of development. The progeny from both normal and intergrading Rabbit-Ear rogues has been in all cases normal rogue. It is of interest to know that in the three cases mentioned the intergrading rogues occurred in progenies of typical plants. No Rabbit-Ear rogues have ever been observed by the author to give rise to any type-like plants.

EXPERIMENTAL METHODS.

In growing pure-lines of either type or rogue plants the flowers were not ordinarily protected from cross pollination. Among the thousands of typical plants grown under observation, only one case of uncontrolled crossing in the field has been recognized. With the exception of the rogues here described the amount of cross-fertilization which usually takes place in peas varies considerably, according to the observations of different workers. White (1) examined 10,000 green-seeded peas grown at the Brooklyn Botanical Garden and found no evidence of any of them having been crossed with a yellow-seeded variety that was growing in close proximity. Opposed to the experience of White and of the present writer is that of Mr. George Starr of the Rice Seed Company. Mr. Starr has informed me that in growing pure lines of Gradus derived from single plant selections he found in one season that the percentage of crossed plants was very high. No exact figures were available, but the progenies of a number of plants indicated that out-crossing with at least four other varieties had occurred. These results were typical for only one season, and would indicate that under very unusual conditions dehiscence of the anthers might be delayed until the flower had opened. If a delay of this kind occurred it would be possible for cross-pollination to be effected by bumble bees.

In the case of the Rabbit-Ear rogues the percentage of volunteer crosses seems normally to be larger than in the type, and in the future it seems advisable to protect the plants during the flowering period. The difference in the amount of normal cross-pollination which takes place in the type and in the rogue plants is accounted for by the smaller flowers and the occasional failure of the rogues to produce good pollen or to shed their pollen before the flower opens.

In making crosses the usual procedure in carrying on artificial pollination in peas was observed, with the additional precaution that in nearly all cases the crossed flowers were protected by a small gauze bag. The pollen on the keel of an unopened flower of the staminate parent was applied to the stigma directly after emasculation of the flower of the pistillate parent. The forceps used were washed in 95% alcohol after each operation. The plants used in making crosses were descended from parents whose progeny had been under observation at least two generations. The variety most intensively studied has

been Gradus, seed of which was first obtained from the J. B. Rice Seed Company of Cambridge, New York.

OCCURRENCE OF MUTATIONS.

Rabbit-Ear rogues are known to arise *de novo* from type plants or from various intergrading forms. To illustrate the numerical relations that exist between the type and the Rabbit-Ear rogue in families of Gradus in which they occur, the results of the past season (1918) are given as typical. From 150 type plants selected in 1917 were raised over 2,500 plants in 1918. Of the 150 families grown only one produced any Rabbit-Ear rogues. In this family of 19 plants (Record No. Sag. 66) three were typical Rabbit-Ear rogues and the other 16 were type plants. Twenty-eight typical plants of another strain, and belonging to the F_3 generation from a plant (G 37) selected in 1916, gave in 1918 a total of 312 F_4 plants. Two of the 28 families produced rogues in the ratio of 14 type to 1 Rabbit-Ear, and 21 type to 1 Rabbit-Ear, respectively. Another F_3 family descended from the same parent, G 37, contained in 1918, 12 type plants, and one plant with type-like foliage and small rogue-like pods. In all, adding together the results from all Gradus families in which Rabbit-Ear rogues occurred, we get a total of 5 rogues to 51 type plants, or 9.6 per cent.

BEHAVIOR OF RABBIT-EAR ROGUES ON CROSSING WITHIN THE GRADUS STRAIN.

In 1917, forty-eight crosses were made between Rabbit-Ear rogue and type plants. In 1918 from these crosses were raised to maturity 148 plants. An attempt was made to classify the hybrids when they had developed to the 5th node. As a great amount of variability existed in the shape of the stipules it was decided to group the seedlings arbitrarily as type-like, intermediate (stipules intermediate between the two parent forms), and rogue-like. Many seedlings were found injured by fungus attacks, and such plants were lumped together in a group as aberrant. It was noted that F_1 plants from one cross might be fairly uniform in appearance, or the individuals might vary considerably, or the reciprocal crosses were unlike in the seedling stage. At maturity it was found that all the F_1 plants, with one exception, were like the Rabbit-Ear parent. A few hybrids of the cross (Gradus type x Rabbit-Ear, and reciprocal), which have been carried into the F_2 and F_3 generations, were Rabbit-Ear rogues at all stages in development. The same results were found true for several crosses of type and Rabbit-Ear rogue plants in other varieties, from which F_2 and F_3 generations have grown. Table 1 shows the results of classification of the progenies in the seedling stage, and later, at maturity. As mentioned before, when classified at maturity the hybrids were, with one exception, indistinguishable from the Rabbit-Ear parent, not only in the character of the stipules but in all the characters that differentiate the rogue from the type. The one exception occurred in the protected cross (G. 19-1-3, R. E. rog. x G 13-1-6-1 type). Four plants were grown from this cross in

1918, and in the seedling stage two were classified as intermediate, one as rogue-like, and one as aberrant. At maturity all were Rabbit-Ear rogues except the one first classified as rogue-like, which was an intergrading form, with type-like foliage and small rogue-like pods. The reciprocal of this cross gave four Rabbit-Ear rogues that were recognized as such at all stages of growth.

None of the plants so far described have been grown to the second hybrid generation, but several crosses made in 1916 have been. The F_1 plants of the cross Rabbit-Ear rogue x type and reciprocal gave a total of 22 plants in the F_2 generation, which were all rogues at all stages in their development. The results are given in Table 2.

Three crosses of Rabbit-Ear rogue x Rabbit-Ear rogue gave in the first and second generations only Rabbit-Ear rogues. The plants of both hybrid generations were like the parent plants in all respects. (See Table 3).

Considering again the results in the F_1 generation of crosses between type and rogue plants, it is seen that no matter which way the cross is made the resulting seedlings vary in regard to the amount of resemblance to one or the other parent. A summary of the classification of the seedlings given in Table 2 shows the intermediate to be the largest class, while the rogues are second in number, and the aberrant plants least frequent. Plate X (figs a and b) shows type and rogue seedlings. Plate XI (figs. a, b and c) shows the three classes of hybrid seedlings. Because of the variation in stipule shape in the young F_1 plants it was thought that the best measure of the difference between the hybrids and their parent forms could be obtained by getting the ratio of the length to the width of stipule in the three forms, namely, pure types, pure rogues and hybrids. To this end measurements of the stipules from the 4th to the 9th nodes were made and the ratios computed. From the F_1 hybrids 69 plants were measured, and from the parents 49 types and 43 Rabbit-Ear rogues. Where possible the type and rogue plants measured had been grown from self-fertilized seed of the hybrid plants measured. Table 4 gives the frequency distributions of the ratios so obtained expressed in percentages. Due to disease and mechanical injury, the same number of stipules could not be measured at each node in any one category of plants. It was necessary, therefore, to express the class frequencies at each node as percentages of the total number of stipules measured at that node before calculating the statistical constants. A glance at the three distributions discloses the close similarity of the hybrid to the rogue parent. The similarity is shown in both the range of variation and in the distribution of the modal classes. The resemblance is further accentuated in the results given in Table 5 and Figure 3. In Table 5 are shown the mean, standard deviation of the ratio, and the coefficient of variability as calculated for each node separately and as determined for all the nodes of each kind as a whole. Figure 3 gives the graphic result of plotting the mean ratio for each node in each of the three forms. The per-

pendicular lines on the curve are proportional to the standard deviation for the ratios calculated at each node. The nodes are numbered horizontally and the ratios indicated vertically. Plate XII, figs. a and b, are of type and rogue plants, respectively, about one week before the measurements were made. Plate XIII shows a comparable hybrid plant.

Considering the frequency distributions at each node separately in the case of the hybrid and the Rabbit-Ear parent, it is seen that the variability in the ratios is of the normal type. In going from the lower to the upper parts of the plant there is a shift in the mean. In the hybrid the change is a progressive one toward the condition found in the Rabbit-Ear rogue. At the 4th node of the rogue the mean is 2.0 and at the 9th node it has increased to 2.5. In the type plant there is very little difference in the mean between the lower and upper parts, the mean being 1.70 and 1.75 for the 4th and 9th nodes, respectively. The hybrids show a greater variability than either parent in this respect, beginning at the 4th node with a mean ration of 1.72, which gradually increases until at the 9th node it is 2.48.

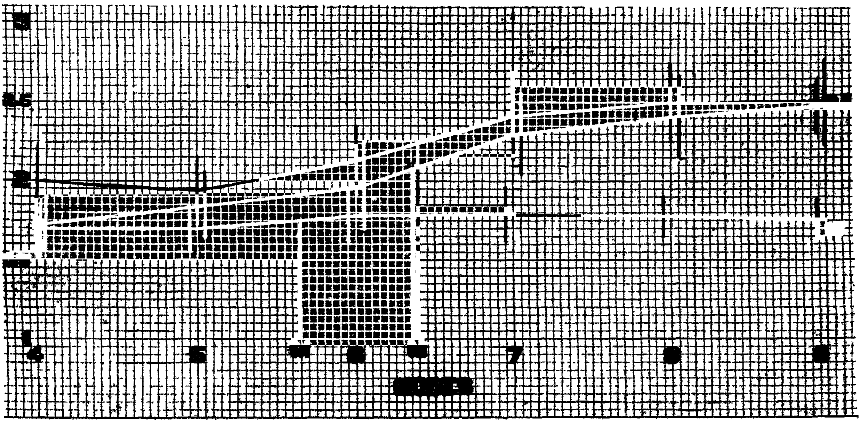

FIGURE 3. Curves obtained by plotting for each node the mean ratio $\frac{\text{length of stipule}}{\text{width of stipule}}$ in Rogue, Hybrid, and Type plants, based on data in Table 5. The upper curve is for the Rabbit-Ear Rogue, the middle curve for the Hybrid, and the lower for the Type. The perpendicular lines on the curves are proportional to the value of σ at each node. The lines from the base to a point on the curve indicate the position of the mean for the plant as a whole. The nodes are indicated horizontally and the ratios vertically.

At the 4th node the ratio is very close to that of the type; at the 5th and 6th nodes it is intermediate between the two parents, and from the 7th to the 9th nodes it is unmistakedly near that of the rogue. Comparing the plants as a whole a different situation might be supposed to exist, as the mean ratio for all nodes of the hybrid is 2.118, intermediate between 1.765 for the type

and 2.259 for the Rabbit-Ear parent. The coefficient of variability for the hybrid is 17.79, as compared with 15.00 in the rogue and 8.66 in the type. Although the Rabbit-Ear rogue is more variable in regard to width of stipule than its typical parent, nevertheless the difference between the two forms is in the nature of a discontinuous variation. It is evident that the greater variability of the rogue dominates in the hybrid offspring.

A similar condition has been reported by Shull (2, 3). He found in Oenothera that mutational changes were often accompanied by increased variability of the affected organs. Thus a statistical study of *Oenothera Lamarckiana* and its dwarf mutation *nanella* showed a great increase in variability correlated with a decrease in plant height of the latter. An increase in the mean number of branches and total branch length of mut. *rubrinervis* was accompanied by a marked increase in variability over that found for the same parts in plants of the parent species (*Oe. Lamarckiana*).

BEHAVIOR OF GRADUS RABBIT-EAR ROGUE CROSSED WITH OTHER VARIETIES THAN GRADUS.

Beside the crosses between Rabbit-Ear rogue and Gradus type several crosses were made between type plants of Peter Pan and of Thomas Laxton with Gradus Rabbit-Ear rogues. Peter Pan and Thomas Laxton are varieties differing from Gradus in some respects, but like Gradus, in that they both produce Rabbit-Ear rogues. Such rogues differ from those of Gradus only as the type plants of both varieties differ from Gradus, i. e., chiefly in pod shape and plant height. None of these hybrids have been carried past the first generation, but in every case the Rabbit-Ear characters have been dominant and behaved as in the first generation of crosses with Gradus type. The results are included at the end of Table 1, but are not included in the summary.

RABBIT-EAR ROGUES IN PETER PAN VARIETY.

Comparable results were obtained in the first, second and third generations of the cross Peter Pan type x Peter Pan R. E. rogue, and reciprocal. Also the back-cross, Peter Pan type x (P. P. type x P. P. R. E. rog.) —F_1, R. E. rog., gave a like F_1 and F_2 generation. Although the number of individuals was small in each cross and the number of varieties used was not large, yet these results coupled with those of other workers would indicate that the behavior of the Rabbit-Ear rogue, when crossed with type plants of other varieties that produce Rabbit-Ear rogues, is the same, no matter what typical plants are used in the cross. At the same time, although there is no apparent segregation of the rogue factors in such a cross, it has been noted by Bateson and Pellew (4) that such characters as pod shape and color of cotyledons show the expected Mendelian segregation.

GRADUS RABBIT-EAR ROGUES CROSSED WITH NON-ROGUE-PRODUCING VARIETIES.

From my own observations as well as from the experience of others, it would seem that not all peas with wide stipules give rise to Rabbit-Ear rogues. From evidence that must be carefully verified, it would seem that Rabbit-Ear rogues from Gradus, for example, when crossed with type plants of varieties that do not produce Rabbit-Ear rogues, give results very different from those obtained in crosses with type plants of Gradus. Gradus Rabbit-Ear rogues when crossed with type plants of a non-Rabbit-Ear producing variety seem to give an F_1 generation with stipules that are intermediate in width between the rogue and the other parent. In the F_2 generation a segregation takes place, so that in regard to shape of stipules, at least, there seems to be a wide range of variation. Plants exceeding the wide-stipuled parent in stipule width are found and plants about the same as the rogue, with regard to this character, are also produced. Between the two extremes lie a large number of intermediate forms, many of which repeat the splitting in the next generation. A few of the wide-stipuled segregates may breed true and some split into various forms in the F_3. The Rabbit-Ear-like plants all seem to breed true. No data have been obtained on the behavior of the various segregates when crossed back with Gradus rogue and type plants. Crosses to verify the above statements were made in 1918.

RESULTS OF OTHER INVESTIGATORS.

In 1915 Bateson and Pellew (4) reported the results of a somewhat similar study of rogues in Early Giant (E. G.), Duke of Albany (D. A.) and Ne Plus Ultra (N. P. U.) Early Giant is a special strain of Gradus developed in England by Sutton & Sons. The genetic behavior of the Rabbit-Ear type of rogues was found to be like that of Rabbit-Ear rogues in Gradus. The authors give additional facts concerning the hereditary behavior of various intermediate (intergrading) forms. Intermediate plants with type-like foliage and rogue pods when crossed with type plants gave in the F_1 generation progenies either all rogues, intermediate and rogues, or type plants and intermediates. In succeeding generations the various sorts of F_1 plants behaved genetically like similar plants which arose *de novo* from type plants.

It was found that the intermediates were of two classes, which could be separated only by their genetic behavior. One class produced a larger number of type plants than rogues and a second class was found in which the proportions were reversed. In a later paper (5) it was noted that if the pods from the upper and lower nodes of intermediate plants were sown separately, the greater number of rogues came from seeds produced on the upper part of the parent plant. This was true in the case of intermediate forms which threw a larger number of rogue than type plants in their progeny. Intermediates, which produced only a few rogues, with many type plants, showed no regularity in the distribution of rogues from seed produced on different parts of the plant.

In addition to the intermediate described as having type-like foliage and rogue pods, Bateson and Pellew describe another form that corresponds to what the present author calls an "intergrading Rabbit-Ear rogue." Their later communication (5) does not make it clear which form of intermediate produced a majority of type plants, or that there was any difference between the two forms of intermediates in this respect.

Three exceptions to the normal behavior found in crosses between rogue and type plants were noted by Bateson and Pellew. The first exception was an F_1 plant from the cross E. G. rogue x E. G. type. Instead of being a rogue at maturity the plant had type stipules and rogue pods. In succeeding generations it behaved genetically like a type plant, except that some of the offspring would occasionally have curved pods. The second exception was in the cross D. A. rogue x D. A. type, which gave an F_1 generation of three rogues and two intermediates. The latter were comparable to the intermediates found in Early Giant. The offspring of the intermediates have not yet been described. The third exception was in the nature of a bud-sport. An F_1 rogue from the cross D. A. rogue x E. G. intermediate gave off from the main stem a branch which was type-like, while the rest of the plant was a thorough rogue. Seed saved from the rogue parts gave only rogues in the next generation, while seed saved from the type parts gave some type-like plants in addition to many rogues. The authors give no data in regard to the behavior of the hybrids when Rabbit-Ear rogues are out-crossed with varieties that do not produce Rabbit-Ear rogues.

The production of rogues by type plants has been thought by Bateson and Pellew (4) to be connected with some instability of the germ plasm related to the great lateral extension of the foliar parts of type plants. It is suggested that type plants may be considered a mosaic of rogue and type tissue, type tissue giving rise to the type gametes and rogue tissue to the rogue gametes. The behavior of the F_1-generation resulting from crosses between type and rogue plants is explained by assuming that in the seedling stage somatic segregation of the type and rogue factors takes place so that at maturity the type elements are excluded from the germ lineage. The weakness in a hypothesis involving somatic segregation lies in the fact that no mechanism is known by which somatic segregation of factors can take place.

White (1) has suggested that the rogues are similar to what Emerson (6) calls a "recurring somatic mutation." A somatic mutation, in the sense in which Emerson uses the term, implies that the difference between the type and the mutation is a difference due to a factor change, or point mutation in a chromosome, taking place during ontogeny. Such a mutation would be comparable to those found by Morgan and his co-workers (7) in Drosophila and would be expected to show Mendelian inheritance. The data at hand are not sufficient to allow such an interpretation at present.

Genetical experiments are in progress to test the linkage relationship, if possible, of the rogue factors with other factors which have been found to show Mendelian behavior. The phenomenon of true-breeding hybrids has been interpreted by Muller (8) on the assumption of its being due to the action of a pair of balanced lethal factors. It may be that the inheritance of the rogue type is complicated by the presence of balanced gametic lethals. To test the possibility a cytological study will be made of pollen formation in the type plants which produce rogues, in the rogues, and in type plants of varieties that do not produce rogues. Until the results from the two lines of investigation are known it would seem premature to suggest an explanation which might account for the facts so far obtained.

In conclusion, and as a statement of the problem, the facts which even a tentative hypothesis would have to consider may be briefly restated.

1. The change from type to rogue may manifest itself either from the earliest stages of development of the plant or later during its ontogeny. The first gives a plant called here a Rabbit-Ear rogue and the second change gives an intergrading Rabbit-Ear rogue. (Confirmation of Bateson and Pellew, 1915).

2. Between the type and Rabbit-Ear rogues are various sorts of intermediates or intergrading plants that differ in the proportion of rogues found among their offspring. (Bateson and Pellew, 1915.)

3. The change from type to rogue seems to be essentially a quantitative one, affecting ten or more characters and involving such organs as the stem, foliar parts, floral envelope, pods and seeds. In the latter there may be a qualitative change, causing the green seed to be bitter in the rogue, while that of the type is sweet to the taste. (Confirmation of Bateson and Pellew, 1915.)

4. Rabbit-Ear rogues, from whatever source, breed true. (Confirmation of Bateson and Pellew, 1915.)

5. The change from type to rogue would seem a reversible one, so that on rare occasions Rabbit-Ear rogue plants may produce a branch that is type-like in foliage characters. (Bateson and Pellew, 1915.)

6. Rabbit-Ear rogue x type and the reciprocal hybrid are variable in the seedling stage and may resemble either the type or rogue parent, or be intermediate in form. At maturity, with rare exceptions, the hybrids are like the rogue parent. It must be emphasized that the change, even in the individual, from type to rogue is a gradual change. It is true for both the intergrading forms and the F_1 hybrid. The fact is well demonstrated by the results of measuring the stipules at the various nodes of the hybrids in which the change takes place. (Figure 3.) (Confirmation of Bateson and Pellew, 1915.)

7. In the seedling stage the rogue plants are more variable in regard to the ratio of length to breadth of the stipules than are the type plants. In this regard the hybrid seedlings resemble the Rabbit-Ear parent, even exceeding it in variability. (Table 5.)

8. In exceptional cases the hybrids discussed in (6) may at maturity have type-like foliage rather than Rabbit-Ear foliage, although the pods resemble pods of the latter. (Confirmation of Bateson and Pellew, 1915.)

9. The hybrid rogues in succeeding generations behave genetically the same as do rogues which arise *de novo* from type plants. There is apparently no segregation during sporogenesis of the factors which diffenentiate the type from the rogue plants. (Confirmation of Bateson and Pellew, 1915.)

10. In the same cross in which we do not have Rabbit-Ear characters segregating in a Mendelian manner we may have other characters such as shape of pod, color and surface of seeds, etc., segregating according to expectancy. (Bateson and Pellew, 1915.)

11. Although not definitely proved, there is some evidence that rogues when crossed with typical plants of varieties that do not produce Rabbit-Ear rogues show a segregation in regard to width of stipule in the F_2 and following generations.

12. Intermediates having a large proportion of rogues in their offspring as compared with the number of type plants, produce more of the rogues from the upper part of the plant than from the lower part of the parent plant. There is no regularity in the distribution of the rogue offspring from different parts of intermediate plants which throw a small percentage of rogue plants. (Bateson and Pellew, 1915.)

13. Rogues are not produced from either kind of intermediate plants with such regularity that a definite ratio of rogue to type plants can be demonstrated. (Confirmation of Bateson and Pellew, 1915.)

14. The rogues are not comparable in appearance, so far as the present author knows, to any existing form of pea. They are certainly not comparable to any the author has seen growing, although about 250 American and foreign varieties of peas have been under observation at one time or another.

15. No difference has been found in the number of chromosomes in the type and rogue plants, the number being 14 in both. (Confirmation of Bateson and Pellew, 1915.)

16. When any intervarietal cross is made between type and rogue plants belonging to any varieties that throw rogues, the results are the same, in regard to the rogue characters, as if the rogues were crossed with type plants of the variety within which the rogue arises. (Confirmation of Bateson and Pellew, 1915.)

17. Rabbit-Ear rogues crossed with Rabbit-Ear rogues give only rogues in the F_1 and succeeding generations. (Confirmation of Bateson and Pellew, 1915.)

The author wishes to acknowledge his indebtedness to Professor Bartlett for generous aid and valuable criticism.

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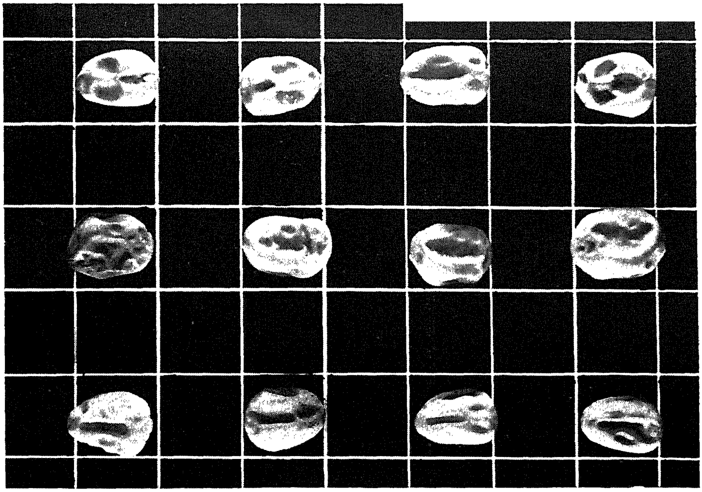
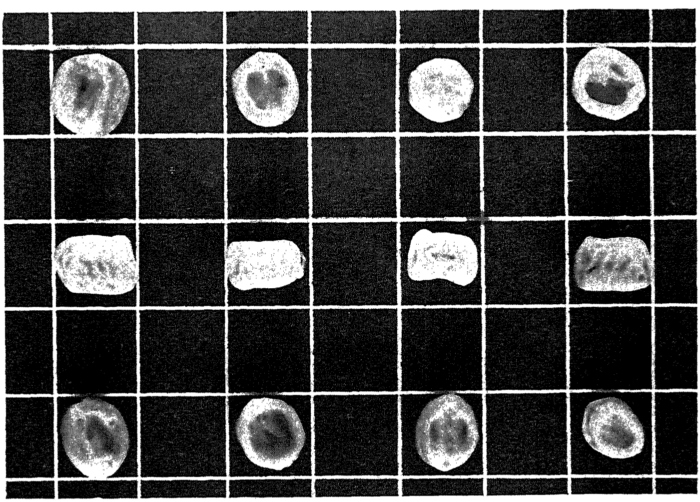


a



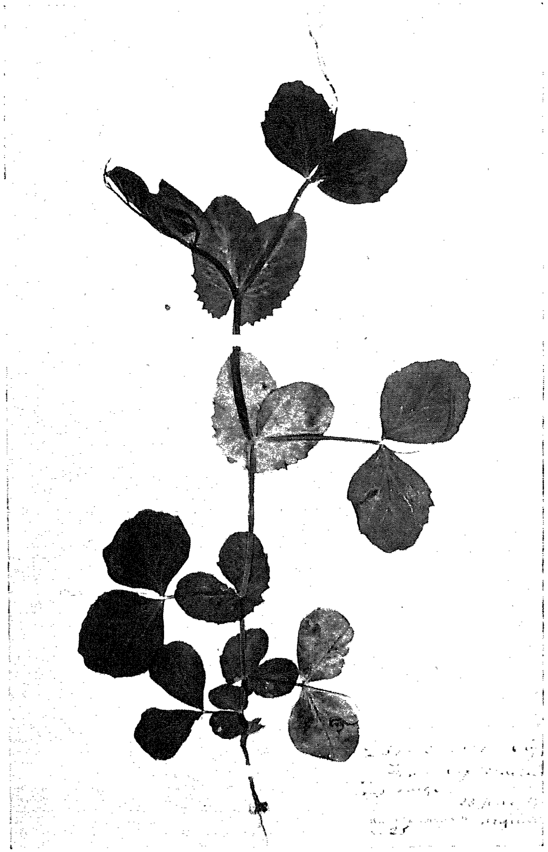
b


23-1-1-17. rogue.

PLATE X

a b

a b c



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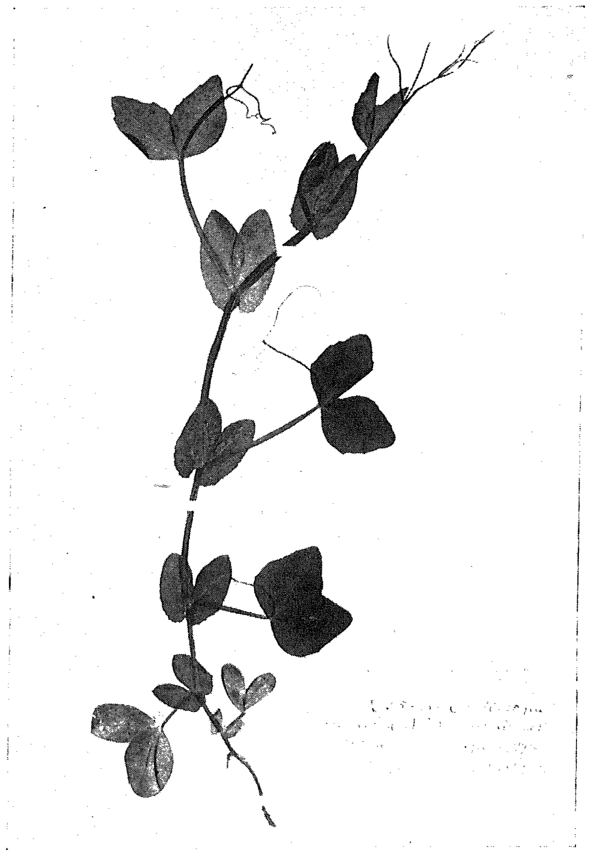

b

TABLE 1.—Classification of Seedlings and Mature Plants of Crosses between Gradus Rabbit-Ear Rogues and Type Plants of Varieties that produce Rogues. Part 1, Gradus rogue × Gradus type, and reciprocal; part 2, Gradus rogue × type plants of Peter Pan (P. P.) and of Thomas Laxton (T. L.).

PART 1

Cross	Seedling	Mature plant
(G13–1–6–1 type × G19–1–3 R. E. rog.)	—1 type	R. E. rogue
	—2 type	"
	—3 interm.	"
	—4 interm.	"
(G37–4–2–2 type × R715–4–1 R. E. rog.)	—1 interm.	"
	—2 interm.	"
	—3 rogue	"
(G37–3–1–1 type × G25–3–6 R. E. rog.)	—1 type	"
	—2 type	"
	—3 type	"
	—4 aberr.	"
	—5 interm.	"
	—6 interm.	"
	—7 interm.	"
	—8 interm.	
	—9 interm.	
(S16–2 type × S10–2 R. E. rog.)	—1 rogue	R. E. rogue
	—2 interm.	"
(G37–1–11–1 type × R715–3–2 rog.)	—1 aberr.	R. E. rogue
	—2 rogue	"
	—3 rogue	"
	—4 aberr.	
(G13–2–2–1 type × G26–2–5–1 R. E. rog.)	—1 interm.	R. E. rogue
	—2 aberr.	"
	—3 interm.	"
	—4 interm.	"
	—5 aberr.	"
	—6 interm.	"
(G29–1–3–1 type × G23–1–1 R. E. rog.)	—1 interm.	"
	—2 rogue	"
	—3 rogue	"
	—4 rogue	"
	—5 aberr.	"
(G37–4–5–2 type × R715A–1–10 R. E. rog.)	—1 interm.	"
	—2 interm.	"
	—3 interm.	"
(G37–4–5–1 type × R715A–1–2 R. E. rog.)	—1 rogue	"
(G13–2–1–2 type × G25–3–4 R. E. rog.)	—1 interm.	"
	—2 interm.	"
(G12–2–6–1 type × G36–2–5–2 R. E. rog.)	—1 rogue	"
	—2 interm.	"
	—3 rogue	"
(G10–1–8–1 type × G17–1–2 R. E. rog.)	—1 rogue	"
	—2 aberr.	"
	—3 rogue	"
	—4 aberr.	"
(G12–1–1–1 type × G36–2–5–2 R. E. rog.)	—1 aberr.	"
(G37–2–1–1 type × R715–3–1 R. E. rog.)	—1 rogue	R. E. rogue
(G13–2–7–1 type × G26–2–5–1 R. E. rog.)	—1 aberr.	
	—2 type	R. E. rogue
	—3 aberr.	
(G37–4–2–1 type × R715–5–1 R. E. rog.)	—1 rogue	R. E. rogue
	—2 rogue	"
(G37–2–12–1 type × R715–1–2 R. E. rog.)	—1 interm.	"
	—2 aberr.	
(G37–2–11–2 type × R715–2–4 R. E. rog.)	—1 interm.	R. E. rogue
	—2 rogue	"
	—3 aberr.	"
	—4 rogue	"
	—5 interm.	"
	—6 rogue	"
	—7 rogue	

TABLE No. 1—*Continued*

(G37–4–8–1 type × R715–8–1 R. E. rog.)	—1 aberr.	R. E. rogue	
(G37–3–5–1 type × R715–7–1 R. E. rog.)	—1 aberr.	"	
	—2 rogue.	"	
	—3 rogue.	"	
	—4 aberr.	"	
	—5 interm.	"	
(G29–1–1–1 type × G23–2–1 R. E. rog.)	—1 aberr.	R. E. rogue	
	—2 rogue.	"	
	—3 rogue.	"	
	—4 rogue.	"	
	—5 rogue.	"	
	—6 rogue.	"	
(S12–21 type × wR715–7–7 R. E. rog.)	—1 interm.	R. E. rogue	
	—2 interm.	"	
	—3 interm.	"	
	—4 interm.	"	
	—5 interm.	"	
(S12–1 type × S11–4 R. E. rog.)	—1 interm.	"	
	—2 rogue.	"	
	—3 rogue.	"	
	—4 rogue.	"	
	—5 type (extreme)	"	
	—6 rogue.	"	
	—7 type (extreme)	"	
(S16–1 type × S10–5 R. E. rog.)	—1 rogue.	"	
(S13–1 type × G17–1–1 R. E. rog.)	—1 injured.	"	(dwarfed)
(S5–2 type × S10–4 R. E. rog.)	—1 interm.	"	
	—2 aberr.	"	
	—3 aberr.	"	
	—4 interm.	"	
	—5 interm.	"	
(S8–3 type × S15–3 R. E. rog.)	—1 rogue.	"	
	—2 interm.	"	
(S8–1 type × S15–3 R. E. rog.)	—1 aberr.	"	
	—2 aberr.	"	
(S5–1 type × S10–4 R. E. rog.)	—1 aberr.	"	
	—2 rogue.	"	
	—3 aberr.	"	
	—4 interm.	"	
	—5 rogue.	"	
(G36–2–10 R. E. rog. × G13–2–4–1 type)	—1 rogue.	"	
	—2 rogue.		
	—3 rogue.		
(G25–3–2 R. E. rog. × G37–3–1–1 type)	—1 interm.	R. E. rogue	
	—2 type	"	
	—3 interm.	"	
	—4 type	"	
	—5 type	"	
(wR715A–1–8 R. E. rog. × G37–3–1–1 type)	—1 interm.	"	
	—2 type.	"	
	—3 type.		
(R715–3–1 R. E. rog. × G37–3–1–1 type)	—1 interm.	R. E. rogue	
(sR715–7–1 R. E. rog. × G37–3–5–1 type)	—1 type.	"	
	—2 type.	"	
(G37–2–8–1 R. E. rog. × G37–2–9–1 type)	—1 aberr.	"	
	—2 interm.	"	
	—3 interm.	"	
	—4 aberr.	"	
(sR715–7–10 R. E. rog. × S12–1 type)	—1 interm.	"	
	—2 type.	"	
	—3 interm.	"	
	—4 type.	"	
	—5 interm.	"	
(G36–2–5–2 R. E. rog. × G12–1–1–1 type)	—1 interm.	"	
	—2 interm.	"	
	—3 interm.	"	
	—4 interm.	"	
	—5 interm.	"	

TABLE No. 1—*Continued*

(S15–1 R. E. rog. × S9–7 type)	—1	interm.	R. E. rogue
	—2	interm.	"
	—3	interm.	"
	—4	interm.	"
	—5	interm.	"
	—6	interm.	"
	—7	type	. . . .
(R7 15–6–2 R. E. rogue × G37–2–15–1 type)	—1	type	R. E. rogue
	—2	type	"
	—3	type	"
(G17–1–2 R. E. rog. × S13–1 type)	—1	rogue	"
	—2	rogue	"
	—3	rogue	"
	—4	rogue	"
(G26–2–5–1 R. E. rog. × G13–2–2–1 type)	—1	interm.	"
	—2	interm.	"
	—3	interm.	"
	—4	interm.	"
	—5	interm.	"
	—6	interm.	"
(R715–3–4 R. E. rog. × G37–2–11–2 type)	—1	type	"
(G36–2–5–2 R. E. rog. × G13–2–5–1 type)	—1	interm.	"
(sR715–7–11 R. E. rog. × G37–4–5–1 type)	—1	interm.	"
(S15–3 R. E. rog. × S9–3 type)	—1	interm.	"
	—2	interm.	"
(R715–4–1 R. E. rog. × G37–4–2–2 type)	—1	interm.	"
(G19–1–3 R. E. rog. × G13–1–6–1 type)	—1	interm.	R. E. rogue
	—2	interm.	"
	—3	aberr.	"
	—4	rogue	Plant with type-like foliage and rogue-like pods.

SUMMARY

Cross	Seedling: Type	Seedling: Interm.	Seedling: Rogue	Seedling: Aberr.	Mature plant: R.E.Rogue	Mature plant: Type foliage
Type × R. E. rogue	8	37	33	23	95	0
R. E. rogue × Type	14	33	8	3	52	1
Total	22	70	41	26	147	1

PART 2

*(G23–1–1 R. E. rog. × T. L. 9–3 type)	—1	rogue	R. E. rogue	(Blunt pods)
	—2	rogue	"	"
	—3	rogue	"	"
	—4	rogue	"	"
	—5	rogue	"	"
	—6	rogue	"	"
**(G36–2–8 R. E. rog. × P. P. 711–7 type)	—1	interm.	"	(Tall)
(S4–2 R. E. rogue × P. P. 712–10 type)	—1	type	"	"
	—2	type	"	"
	—3	type	"	"
	—4	type	"	"
	—5	type	"	"
	—6	type	"	"
	—7	type	"	"
(S4–1 R. E. rog. × P. P. 712–10 type)	—1	interm.	"	"
	—2	interm.	"	"

*Gradus rogues and type plants have pointed pods. Those of Thomas Laxton (T. L.) are blunt at apex. Both varieties are tall.

**Peter Pan (P. P.) is a dwarf variety with pointed pods.

TABLE 2. Results in the F_2 generation of Crosses between Gradus Rabbit-Ear Rogues and Gradus Type Plants.

Parent	No. of plants	Seedling	Mature plant
(G26–2–3 R. E. rog. × G29–1–1 type)—1 R. E. rog.	1	rogue.....	R. E. rogue
(G37–1 type × G32– 2R. E. rog)—4 R. E. rog......	5	rogues....	,,
(G9–2–1 type × G36–2–7 R. E. rog.)—2 R. E. rog...	17	rogues....	,,

TABLE 3. Results in the F_2 generation of Crosses between Gradus Rabbit-Ear Rogues.

F_1 Cross	No. of plants	Seedling	Mature plant
(G15–1 R. E. rog. × G15–2 R. E. rog.)—2 R. E. rog..	2	rogues....	R. E. rogue
(G15–2 R. E. rog. × G15–1 R. E. rog.)—1 R. E. rog..	2	,,	,,
(G16 R. E. rog. × G23 R. E. rog.)—1 R. E. rog.......	6	,,	,,
—2 R. E. rog.......	10	,,	,,

TABLE 4. Frequency distribution of ratio $\frac{\text{length of stipule}}{\text{width of stipule}}$ at the 4th to the 9th nodes in Rogue, Hybrid and Type plants. As the number of stipules measured at each node was not always the same, the ratios in any one class are expressed in percentages.

Ratio	Rogue						
	4th node	5th	6th	7th	8th	9th	Total
1.35......	....	....	....	3.02	....	....	3.02
1.45......	2.66	1.20	0	0	....	....	3.86
1.55......	5.32	2.40	1.16	0	....	....	8.88
1.65......	10.64	6.00	1.16	1.51	....	....	19.31
1.75......	13.30	8.40	3.48	0	0	3.56	28.74
1.85......	9.31	18.00	9.29	0	3.75	3.56	43.90
1.95......	5.32	12.00	10.44	3.02	0	1.78	32.56
2.05......	11.97	25.20	24.36	4.53	2.50	0	64.56
2.15......	10.64	8.40	10.16	4.53	2.50	0	36.23
2.25......	15.96	8.40	16.24	10.35	6.25	5.34	62.54
2.35......	6.65	4.80	10.16	12.08	16.25	5.34	55.28
2.45......	5.32	3.60	3.48	21.14	12.50	14.24	60.28
2.55......	1.33	1 20	4.64	16.61	21.25	28.	73.47
2 65......	0	0	1.16	19.63	16.25	10.58	56.62
2.75......	1.33	0	0	3.02	10.00	8.90	23.25
2.85......	....	....	1.16	0	0	5.34	6.50
2.95......	....	....	....	....	6.25	1.78	8.03
3.05......	....	....	....	....	1.25	1.78	3.03
3.15......	....	....	....	....	1.25	0	1.25
*	75	83	86	66	80	56	....

TABLE 4—Continued

Ratio	4th node	F₁ Hybrid 5th	6th	7th	8th	9th	Total
1.25......	.85	0	1.46	....	....	....	2.31
1.35......	.85	.75	0	.77	....	....	2.37
1.45......	5.10	1.50	1.46	0	....	....	8.06
1.55......	16.15	10.50	1.46	.77	....	....	28.88
1.65......	30.60	16.50	10.22	.77	....	....	58.09
1.75......	22.10	16.50	10.95	.77	1.60	....	51.92
1.85......	22.10	19.50	20.44	4.62	1.60	....	68.26
1.95......	4.25	10.50	13.14	5.39	1.60	....	34.88
2.05......	3.40	18.75	12.41	10.01	8.80	1.35	54.72
2.15......	0	12.00	9.49	11.55	3.20	1.35	37.59
2.25......	.85	9.00	10.95	13.86	12.00	10.80	57.46
2.35......	1.70	.75	3.65	17.71	12.00	20.25	56.06
2.45......	....	0	.73	8.47	17.60	18.90	45.70
2.55......	....	0	2.19	14.63	19.20	24.30	60.32
2.65......	....	.75	.73	6.16	10.40	14.85	32.89
2.75......	....	....	....	2.31	7.20	5.40	14.19
2.85......	....	....	....	1.54	.80	1.35	3.69
2.95......	....	....	....	....	3.20	1.35	4.55
*	117	132	136	129	124	74	....

TABLE 4—Continued

Ratio	Type 4th node	5th	6th	7th	8th	9th	Total
1.35......	5.40	1.08	2.24	....	....	....	8.72
1.45......	6.48	3.24	3.36	6.18	1.08	....	20.34
1.55......	10.80	19.44	8.96	10.30	7.56	9.52	56.58
1.65......	11.88	24.84	11.20	13.39	15.12	21.42	97.85
1.75......	19.44	23.76	30.24	19.57	29.16	33.32	155.49
1.85......	35.64	18.36	20.16	23.69	27.00	19.04	143.80
1.95......	3.24	7.56	13.44	13.39	16.20	10.90	64.73
2.05......	4.32	0	6.72	7.21	2.16	4.76	25.17
2.15......	0	1.08	3.36	6.18	0	0	10.62
2.25......	0	0	0	0	0	0	0
2.35......	1.08	....	....	....	....	....	1.08
*	91	92	89	97	91	42	....

*The figures in horizontal lines marked with an asterisk indicate the actual number of measurements from which the frequency distributions (expressed in percentages) were derived.

TABLE 5. Statistical Constants for Stipule Shape Calculated for each Node Separately and for the Plant as a Whole, based on Data in Table 4.

		4th node	5th	6th	7th	9th	9th	All nodes
Rogue...	Mean	2.001	1.994	2.133	2.411	2.500	2.515	2.259
	σ....	.294	.223	.223	.288	.257	.266	.339
	C. V.	14.70	11.20	10.46	11.53	10.28	10.59	15.00
Hybrid..	Mean	1.725	1.846	1.926	2.308	2.410	2.485	2.118
	σ....	.174	.217	.275	.266	.261	.172	.377
	C. V.	10.11	11.79	14.32	11.56	10.82	6.93	17.79
Type....	Mean	1.705	1.706	1.782	1.797	1.782	1.766	1.765
	σ....	.205	.155	.170	.177	.130	.130	.153
	C. V.	12.05	8.11	9.55	9.88	7.30	7.32	8.66

LITERATURE CITED.

1. WHITE, O. E. Studies of Inheritance in Pisum, II. The Present State of Knowledge of Heredity and Variation in Peas. Proc. Amer. Phil. Soc., *56*:487-588. 1917. Pages cited, 494, 577-580.
2. SHULL, G. H. Statistical comparisons of *Onagra* (*Oenothera*) *Lamarckiana*, with two of its mutants. *In* MACDOUGAL. D. T., Mutants and Hybrids of the Oenotheras. Carnegie Institution of Washington. Publication 24, pp. 36-50. 1905.
3. SHULL, G. H. The fluctuations of *Oenothera Lamarckiana* and its mutants. *In* MACDOUGAL, D. T., VAIL, A. M., and SHULL, G. H. Mutations, Variations and Relationships of the Oenotheras. Carnegie Institution of Washington. Publication 81, pp. 18-55. 1907.
4. BATESON, W. and PELLEW, C. On the Genetics of "Rogues" among culinary peas (*Pisum sativum*). Jour. Genetics, *5*:13-36. 1915.
5. BATESON, W. and PELLEW, C. Note on an orderly dissimilarity in inheritance from different parts of a plant. Proc. Roy. Soc., Ser. B, *89*:174-175. 1915.
6. EMERSON, R. A. The Inheritance of a Recurring Somatic Variation in Maize. Amer. Nat. *48*:87-115. 1914.
7. MORGAN, T. H., STURTEVANT, A. H., MULLER, H. J., and BRIDGES, C. H. The Mechanism of Mendelian Heredity. 1915.
8. MULLER, HERMAN J. Genetic Variability, Twin Hybrids, and Constant Hybrids in a Case of Balanced Lethal Factors. Genetics *3*:422-499. 1918.

EXPLANATION OF PLATES.

Plate VII. Figure a, typical seed of Gradus.
Figure b, Gradus Rabbit-Ear rogue seed.
(The back ground in both figures is ruled into 1 cm. squares.)

Plate VIII. Upper part of mature type plant of Gradus.
(Four-tenths natural size.)

Plate IX. Upper part of mature Rabbit-Ear rogue of Gradus.
(Four-tenths natural size.)

Plate X. Figure a. Seedling of typical Gradus, three weeks old.
Figure b. Seedling of typical Gradus Rabbit-Ear rogue, three weeks old.
(Figs. a and b are two-thirds natural size.)

Plate XI. Figures a, b, c, are of Type-like, intermediate, and Rogue-like seedlings, respectively, from the F_1 generation of the cross Gradus type X Gradus Rabbit-Ear rogue. Figures a and c are from the same cross. All the seedlings were three weeks old when collected. (Figures a, b, c are two-thirds natural size.)

Plate XII. a. Young plant of typical Gradus about five weeks old, collected one week before the stipule measurements were made.
b. Young plant of Gradus Rabbit-Ear rogue of same age as type plant shown in Plate XIIa. (One-fourth natural size.)

Plate XIII. Young plant of cross Gradus type X Gradus Rabbit-Ear rogue in the F_1 generation. Age of type plant shown in Plate XIIa. (Four-tenths natural size.)

OBSERVATIONS ON THE POTATO DISEASE CONDITIONS IN MICHIGAN FOR THE SUMMER OF 1918.

E. F. WOODCOCK.

The results included in this paper were obtained in connection with survey work carried out during the summer of 1918 under the supervision of the Plant Disease Survey of the United States Department of Agriculture The primary object of the survey was to locate Late Blight if it should appear in the state, and take measures to prevent the spread of the disease. In connection with the survey for this partciular disease, which was not found in the state, the potato diseases discussed below were observed.

TIP BURN.

The injury done by this trouble consisted of the destruction of leaf area at a time when the plant was manufacturing food for storage in the developing tubers. As a result of this the yield, especially in the early varieties, was cut down fully 50% in severe cases. Ninety per cent of the counties visited in the lower peninsula showed the trouble, while only 64% of the counties in the upper peninsula were affected. This difference in percentage of distribution throughout the state is due to the fact that most of the lower peninsula suffered from a severe drought during the growing season, while the upper peninsula received sufficient rainfall. The work of E. D. Ball,* suggesting a relation between leaf hoppers and the tip burn, had not come under my observation, so that no complete notes were taken relative to their presence throughout the state.

The percentage of injury in the following table summarizing my observations on Tip Burn has reference to the amount of leaf area killed:

SUMMARY TABLE No. 1

No. of counties disease present	No. of fields visited.	No. of fields disease absent	No. of fields with more than 1 % injury	Per cent infected fields	Per cent clean fields	Per cent fields containing more than 1 % injury
24	328	219	54	33 %	67 %	16 %

RHIZOCTONIA (CORTICIUM VAGUM VAR. SOLANI).

The disease was found in 42% of the fields visited and quite generally distributed. In the early part of the season its presence was evident by the stunting effect on the developing tops. One field in Oakland county showed

*Ball, E. D. Science 48: 194. 1918. Leaf Burn of the Potato and its Relation to the Leaf Hopper.

[1] 21st Mich. Acad. Sci. Rept., 1919.

25% of the hills so affected. In the latter part of the season the diseased plants showed a slight yellowing and an upturning of the leaves along the midrib. In some cases the yellowing was absent. There appeared in some fields the rosette effect and in others the aerial tubers. Stem lesions were quite generally evident. A field of Russet Rurals on stump ground showed 50% of the hills having the upturned leaves.

The summary of my observations given in the table below shows that only about 4% of the diseased fields had over 1% injury. It is thus evident that the disease under soil conditions was not doing any considerable amount of damage to the crop as a whole, but in certain fields the loss might be severe.

SUMMARY TABLE No. 11

No. of counties disease present	No. of fields visited.	No. of fields disease absent	No. of fields with more than 1 % injury	Per cent infected fields	Per cent clean fields	Per cent fields containing more than 1 % injury
22	328	189	28	42 %	58 %	16 %

ARSENICAL INJURY.

The injury caused by this trouble was not evident in sufficient amounts to affect the crop to any appreciable extent. In some cases it was difficult to determine just whether the discoloration and dying of the leaf extremity was due to arsenical injury or to tip burn. Sixty-seven per cent of the fields visited showed the trouble in amounts ranging from a trace to 10%. Only 18% of the affected fields showed the injury in amounts over a trace. Seventy-three per cent of the counties visited showed all the fields to be clean.

BLACK LEG (BACILLUS ATROSEPTICUS.)

This disease was found in 27% of the fields visited, being much less abundant in the southern part of the state than elsewhere. This distribution of the disease was very likely due to the fact that the pathogene has not yet been inroduced into the southern part of the state. In many counties the farmers are beginning to realize the need of planting disease-free seed. Removal of the affected hills is being practiced quite generally. In some of the diseased plants the bacteria had proceeded along the stolon to the small new tubers, there forming a pocket of bacteria slime in the stem end.

In connection with the summary given in the table below, it is interesting to know that the average percentage of injury for the entire number of diseased fields was 1.8%. Since this disease prevents the formation of any marketable potatoes on the affected plant, the above percentage may well be taken as representing the loss to the farmer:

SUMMARY TABLE No. III

No. of counties disease present	No. of fields visited.	No. of fields disease absent	No. of fields with more than 1 % injury	Per cent infected fields	Per cent clean fields	Per cent fields containing more than 1 % injury
20	328	240	21	27 %	73 %	6 %

FUSARIUM WILT (FUSARIUM OXYSPORUM).

This disease cut down the yield throughout the state to some extent by the formation of small unmarketable potatoes in the affected hills. The distribution of infection through the state was not observed to be correlated wtih moisture conditions. In only a few cases were the farmers practicing the method of cutting off the stem end of the seed piece to determine the presence or absence of the disease. Seventy per cent of the counties visited showed the disease, 21% of the observed fields being infected. The following table, summarizing my observations, shows that of the 71 infected fields observed only 6% had the disease present in amounts over 1%:

SUMMARY TABLE No. IV

No. of counties disease present	No. of fields visited.	No. of fields disease absent	No. of fields with more than 1 % injury	Per cent infected fields	Per cent clean fields	Per cent fields containing more than 1 % injury
21	328	257	20	21 %	69 %	6 %

EARLY BLIGHT (ALTERNARIA SOLANI).

Twenty-three per cent of the counties visited showed the disease present, it being more abundant in the upper peninsula than elsewhere. It is probable that the greater amount of disease in the regions mentioned was due to the greater abundance of moisture present, thus facilitating the spread of the pathogene. In most of the fields the disease was more or less local. Its presence did not seem to interfere with the normal development of the plant to any marked extent, except in a few cases. In the summary table given below the percentage of injury indicates the amount of leaf surface killed. Since the 41 diseased fields showed only 7% of the fields with over 1% injury, the decrease in yield was not marked:

SUMMARY TABLE No. V

No. of counties disease present	No. of fields visited.	No. of fields disease absent	No. of fields with more than 1 % injury	Per cent infected fields	Per cent clean fields	Per cent fields containing more than 1 % injury
7	328	287	22	12 %	88 %	7 %

LEAF ROLL.

This trouble was observed as a trace only in Oakland, Schoolcraft, Luce and VanBuren counties. As two of these counties are located in the upper peninsula, and two in the lower peninsula, it is evident that it is not limited to any one particular section of the state. The small amount of leaf roll in the state was not cutting down the yield to any appreciable extent.

MOSAIC.

This disease was not observed to any extent over the lower peninsula, but was quite general in the upper peninsula. Of the 30 counties visited, only six showed the disease; five of these, i. e., Delta, Schoolcraft, Baraga, Marquette and Ontonagon counties being in the upper peninsula.

The average percentage of infection for the diseased fields was 11%. Of the counties visited, Marquette showed every field infected, while none of the other counties showed over 28% of the observed fields infected. The highest percentage of infection for the various varieties was as follows: Triumph 75%, Green Mountains 46%, Mayflower 40%, Russet Rural trace. On the variety Triumph, the disease appeared to stunt the plants quite markedly, whereas in the other varieties the affected plants in many cases had a normal spread of foliage with the characteristic mosaic leaves. Investigation showed that the disease was cutting down the yield only to a slight extent in those sections where it had been occurring annually.

CURLY DWARF.

This disease was found in only three of the 30 counties visited. Eighteen fields in Cheboygan county showed a trace in three fields; 15 fields in Charlevoix county, a trace in one field; and 7 fields in Mecosta county, a trace in one field. The susceptible variety in each case was Russet Rural. The above facts go to show that Curly Dwarf was a minor factor in cutting down the crop.

LIGHTNING INJURY.

Four cases were observed in the state during the summer. All these were found in the lower peninsula and in separate counties. The affected spot in each did not exceed two rods in diameter, and was circular in form. There was no indication that the electricity had followed the rows. Evidence seemed to show that the injury radiated from a common center, even though there was no central spot where the soil had been disturbed by the bolt. In some cases practically all the plants had been killed, while in others some of the plants remained alive. The injury came so suddenly that the killed plants wilted down immediately without their tissues becoming browned. The stems usually were dry and blackened where the electric current had passed. The stem below the ground appeared to immediately undergo a dry rot. The new

tubers, where formed, soon rotted in the ground. In some cases, where the plants were not entirely killed, while still prostrate, they began to revive at the tip, and this portion would become erect and develop in a normal way.

Although the above observations do not in all cases show a correlation between weather and the prevalence of the disease, as for example, the distribution of Black Leg, there were some quite evident correlations observed. Early Blight was evident almost exclusively in the upper peninsula, where there was plenty of moisture. The fact that Michigan did not have a cool, wet July, followed by an August with moderate or heavy rainfall, and that there was no epidemic of Late Blight, is further proof that the relation between weather and Late Blight suggested by G. H. Coons * holds true. Fusarium Wilt showed no relation to weather, but rather was related to soil and general cultural conditions. Based upon my observations, I can make out no connection between the occurrence and severity of Tip Burn and the different climatic regions of the state. This, however, is a trouble to which great attention should be given, regardless of whether Tip Burn is a stigmonose or a disease caused by a pathogene transferred by the Leaf Hopper.

Unsatisfactory and incomplete as the results of the survey were, the observations have already proved to be of such value as indicating further research that it seems highly desirable to continue work along this line, perhaps on other crops as well, in succeeding years.

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*Special Bulletin 85. Michigan Agricultural College Experiment Station.

GUIDE TO THE LITERATURE FOR THE IDENTIFICATION OF FUNGI —A PRELIMINARY OUTLINE FOR STUDENTS AND OTHERS.

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Our one great work for the identification of fungi is, it almost goes without saying, Saccardo's Sylloge Fungorum. In this ponderous work, written entirely in Latin, one may expect to find described all species of fungi that have ever been recognized and named. But the very vastness of the work (twenty-two volumes up to date, including descriptions of over 66,000 species of fungi) militates against its usefulness, especially for comparative beginners in the study of fungi. Furthermore, such a work does not lay claim to be more than a carefully supervised compilation. It is manifestly impossible to expect the author to be able to know every one of the species included in the work, and accordingly exclude those newly described forms that he judges to be identical with species already described. It is true that he is able to do this in many cases, but by far not with all species described every year. He also is enabled, because of his wide acquaintance with the field, to correct false assignments of new species to genera, in which it is manifest that they do not belong. The very fact, however, that in this work have been brought together the descriptions of all known fungi has greatly stimulated the study of these plants so that supplement after supplement has had to be issued to include the species described since the first eight volumes have appeared. As a result, one must wade through pages of descriptions in many different volumes, carefully balancing this man's description, in which certain points are emphasized and others neglected, with that man's description in which, perhaps, the emphasis and neglect are just reversed. The result is all too often a desperate seizing upon some one description that is not too far different from the fungus in hand, and an unexpressed prayer that it may not be necessary to repeat the performance soon. A still greater difficulty, however, for many students is their very deficient training in Latin. It is a sad fact that many students now enter colleges and universities without having studied even one hour of this language. To such, even the comparatively small vocabulary and simple constructions of the family, generic and specific descriptions of Saccardo are an unsurmountable barrier.

The necessary lack of critical discrimination as to the species incorporated in the work also makes Saccardo somewhat unsatisfactory. Furthermore, until one is quite familiar with the various groups of fungi, many of them are not easily understood without reference to illustrations. To be sure, Saccardo lists carefully all such figures, but their absence in the work itself

makes it less valuable for many who consult it. Then opinions as to the limits of families and genera are constantly changing, changes that are hard to reflect in such a work extending over a period of more than thirty years. Accordingly we find that specialists have made close studies of orders, families, genera, or even small groups of critical species, examining all the available specimens, particularly where possible, the specimens in the hands of the original describer of each species. From these are drawn up new descriptions, all based upon the same comparative structures, often illustrated copiously and usually accompanied by new keys, careful reduction of synonyms, etc. Could the literature of such studies be made easily accessible to students it would make the identification of fungi far easier, at least in some groups.

The need for a list that would refer one to these monographs and minor studies as well as to other works in other languages than Latin that might, in part, take the place of Saccardo, led the writer some time ago to begin the preparation of such a bibliography. The present very incomplete list is the outcome of this attempt to supply this need. It must not be looked upon as an attempt to produce a complete bibliography of systematic mycology; that would take a book half as large as Lindau's Thesaurus. The following have been the aims in preparing the list:

First in the list come the general works covering the whole field of systematic mycology, such as Saccardo, Engler and Prantl, etc. It has been attempted for these, as well as for the smaller more special publications, to list two or more, so that in case one is unavailable another may be consulted. Where a work consists of more than one volume, the main groups of fungi treated of in each volume are indicated. Following next are the names of smaller works, still covering all of the main groups of fungi, but not so extensive in their scope; as well as host indices, etc.

The greater part of the list is devoted to the special monographs and studies of limited groups of fungi. No attempt is made to cover the older literature; with a few exceptions, only those special studies are noticed that have appeared since the first volume of Saccardo saw light. In case of several papers of more or less monographic nature upon the same group of fungi two or three are usually mentioned, but a partial attempt has been made to indicate by position which is the more complete or most helpful. Thus of two or three papers cited, usually the first one mentioned is considered as the most desirable, in whose absence, however, one should consult one of the others. In case, however, one monograph covers a larger geographical area that is placed first.

Where a group of fungi is not found in the list of titles it is an indication that no fairly recent studies on that group are known to the compiler of this list. In that case, the student has no choice but to go to the general works, found at the head of the list.

For a few of the papers, a brief note of comment is added, indicating the scope of the article, range of distribution of the fungi studied, character of the illustrations, etc., insofar as these are not apparent in the citation itself and would be of assistance to the student.

It has seemed undesirable, at least for the present, to attempt to make the list complete for all parts of the world. Only those works are listed that bear upon groups more or less represented in the United States, particularly the eastern half.

Although the writer is firmly convinced that the Slime Molds are animals, and that they have no phylogenetic connection whatever with any group of plants, a couple of standard works on these organisms are listed out of deference to the opinions of the many botanists who still prefer to retain these beautiful little things in their field. They are listed as Mycetozoa, however, not as Myxomyceteae. The Bacteria, although almost certainly true plants, are omitted from this list, inasmuch as their identification requires a training in bacteriology which will at the same time give one acquaintance with the necessary literature. With Professor Bruce Fink, the Lichens are believed to be nothing but fungi with algal hosts, not a distinct class, and probably if we should learn their life history fully, many of them not even deserving to be placed in separate orders. Since most of them are still usually placed on a distinct order, the references to these plants will be found under the Order Lecanorales under the Class Ascomyceteae. It is true that this will place such forms as the Pyrenulales apart from their nearest relatives, but that cannot well be prevented in a list of this sort.

This list cannot be expected to take the place of a general knowledge of the main groups of fungi. To use it to any advantage one must be able to place the organism in the proper class and order, and preferably family also. The student must be able to make use of Saccardo, Engler and Prantl, or Stevens or some other general work, in order to carry the fungus that far, in case his knowledge of fungi has not already progressed far enough to enable him to recognize on preliminary study the group to which it belongs. Then by consulting the appended bibliography it may be seen whether the further steps of identification must be carried to the bitter end by means of Saccardo or whether a monograph or some other work is available on that particular group.

As presented, the list shows many lacunae. Many families, and even orders, are not mentioned. This is due to many factors, viz.: Many groups are still in sad need of critical revision or lie entirely outside of the geographical limits of this paper, or the papers on these groups have been overlooked in the compilation of this list. It is very probable that many omissions will have to be charged to the last head. With the development of the war, much of the foreign literature of the past three or four years has been inaccessible, so that for such publications this list must perforce be several years behind.

hand. Some will doubtless take issue with the failure to include references to large lists of new species described by various authors. These have not been included, except where a generic revision is included in the paper, or where the genus is a large one, with many new species systematically arranged.

A word must be said as to the names employed for the classes, orders, etc. The familiar classes—Phycomyceteae, Ascomyceteae and Basidiomyceteae and the "form class," Fungi Imperfecti, will be recognized by every one. Following C. E. Bessey, the Rusts and Smuts are considered to be sufficiently distinct from the Basidiomyceteae (although perhaps more closely related to them than to the Ascomyceteae) to be raised to the dignity of a separate class, the Teliosporeae. Following many investigators, the Synchytriaceae are considered as being degenerate Chlorophyceae of the class Protococcoideae, and not related to the Phycomyceteae. Ordinal names are all based upon a genus included in that order and end in —ales. Family names are always based upon a genus within the family with the ending --aceae. However, in listing the contents of general works, the names there used are retained.

BIBLIOGRAPHY.

I. General works covering the whole field of Systematic Mycology.

Saccardo, P. A. Sylloge Fungorum omnium hucusque cognitorum. Twenty-two volumes issued up to 1919. Pavia, Italy.

1:	1–768.	1882.	Pyrenomyceteæ.
2:	1–959.	1883.	Pyrenomyceteæ (cont.).
3:	1–860.	1884.	Sphæropsideæ and Melanconieæ.
4:	1–807.	1886.	Hyphomyceteæ.
5:	1–1146.	1887.	Hymenomyceteæ I. Agaricineæ.
6:	1–928.	1888.	Hymenomyceteæ II. Polyporeæ, Hydneæ, Thelephoreæ, Clavarieæ, Tremellineæ.
7:	1–941.	1888.	Gasteromyceteæ, Phycomyceteæ, Myxomyceteæ, Ustilagineæ, Uredineæ.
8:	1–1143.	1889.	Discomyceteæ, Phymatosphaeriaceæ, Tuberaceæ, Elaphomycetaceæ, Onygenaceæ, Laboulbeniaceæ, Saccharomycetaceæ, Schizomycetaceæ.
9:	1–1141.	1891.	Supplement 1. Hymenomyceteæ, Gasteromyceteæ, Hypodermeæ (Ustilaginaceæ and Uredinaceæ), Phycomyceteæ, Pyrenomyceteæ, Laboulbeniaceæ.

10: 1–964. 1892. Supplement 2. Discomyceteæ, Onygenaceæ, Tuberoideæ, Myxomyceteæ, Sphaeropsideæ, Melanconieæ, Hyphomyceteæ, Fossil Fungi.

11: 1–753. 1895. Supplement 3. All groups of Fungi. Generic Index to all volumes.

12: 1–1053. 1897. Index to first eleven volumes.

13: 1–1340. 1898. Host Index.

14: 1–1316. 1899. Supplement 4. All groups of Fungi. Sterile Mycelia.

15: 1–455. 1901. Supplement 5. Synonyms.

16: 1–1291. 1902. Supplement 6. All groups of Fungi. Generic Index to all volumes.

17: 1–991. 1905. Supplement 7. Hymenomyceteæ, Gasteromyceteæ, Uredinaceæ, Ustilaginaceæ, Phycomyceteæ, Pyrenomyceteæ, Laboulbeniomyceteæ.

18: 1–838. 1906. Supplement 8. Discomyceteæ (including Saccharomycetaceæ, Exoascaceæ, Gymnoascaceæ, Tuberaceæ, etc.), Myxomyceteæ, Deuteromyceteæ (=Fungi Imperfecti). Generic index for all volumes.

19: 1–1158. 1910. Index of illustrations of Fungi, A–L.

20: 1–1310. 1911. Index of Illustrations of Fungi, M-Z.

21: 1–928. 1912. Supplement 9. Hymenomyceteæ, Gasteromyceteæ, Ustilaginaceæ, Uredinaceæ, Phycomyceteæ.

22: 1-612. 1913. Supplement 10. Ascomyceteæ, Deuteromyceteæ, Sterile Mycelia.

Volumes 1, 10 and 17 contain bibliographies; Vol. 14 contains an explanation of the arrangement of genera by the spore form and color scheme.

Rabenhorst, L. Kryptogamen-Flora von Deutschland, Oesterreich und der Schweiz. Zweite Auflage. Band I. Winter, Georg. Die Pilze.

This "Volume" on Fungi is so extensive that it is issued as nine separately bound "Abtheilungen", as follows:

1: 1–924. *1 plate and numerous text figures.* 1884. Schizomycetes, Saccharomycetes, and Basidiomycetes. By A. de Bary, H. Rehm, and Georg Winter.

2: 1–928. and Index, 1–112. *Numerous text figures.* 1887. Ascomycetes: Gymnoasceae and Pyrenomycetes. By A. de Bary, H. Rehm, and Georg Winter.

3: 1–1275. and Index, 1–169. *Numerous text figures.* 1896. Ascomycetes: Hysteriaceæ and Discomycetes. By H. Rehm.

4: 1–505. *Figs. 1–74.* 1892.
Phycomycetes. By Alfred Fischer.
5: 1–131. *Numerous text figures.* 1897.
Ascomycetes; Tuberaceæ and Hemiasceæ. By Ed. Fischer.
6: 1–1016. *Numerous text figures.* 1901.
Fungi Imperfecti: Hyaline-spored Sphaerioideæ. By Andreas Allescher.
7: 1–1072. *Numerous text figures.* 1903.
Fungi Imperfecti: Phæosporous Sphærioideæ, Nectrioideæ, Leptostromaceæ, Excipulaceæ and Melanconieæ. By Andreas Allescher.
8: 1–852. *Numerous text figures.* 1907.
Fungi Imperfecti; Hyphomycetes, including Mucedinaceæ and the Phaeosporous and Phaeodidymous Dematiaceæ. By G. Lindau.
9: 1–983. *Numerous text figures.* 1910.
Fungi Imperfecti: Dematiaceæ (Phaeophragmiæ to Phaeostaurosporæ), Stilbaceæ and Tuberculariaceæ. By G. Lindau.

Engler, A. und Prantl, K. Die natuerlichen Pflanzenfamilien.
The parts devoted to fungi (including the Lichens) are the following:
I. Teil, Abteilung 1: 1–513. *Figs. 1–293.* 1897.
Myxomyceteæ, Phycomyceteæ, Ascomyceteæ.
I. Teil, Abteilung 1*: 1–249. *Figs. 1–125.* 1907.
Lichens.
I. Teil, Abteilung 1**: 1–570. *Figs. 1–263.* 1900.
Basidiomyceteæ, including Hemibasidii (Ustilaginales) and Uredinales. Fungi Imperfecti.
This work will enable one to determine the genus of almost any fungus but not the species. It is very helpful because of the illustrations.

Lindau, G. et Sydow, P. Thesaurus litteraturae mycologicæ et lichenologicæ.
1: 1–903. 1908. Authors A. to L., up to 1906, incl.
2: 1–808. 1909. Authors M. to Z., up to 1906, incl.
3: 1–766. 1913. Corrections and additions up to 1910, incl.
4: 1–609. 1915. Applied Mycology, geographical distribution, pathology.
A nearly complete bibliography of all mycological literature up to the close of 1910, arranged alphabetically by the authors. Vol. 4 is arranged by subjects, the plant diseases under their hosts.

Stevens, F. L. The Fungi which cause Plant Disease. 1–754. 1913.
Underwood, L. M. Moulds, Mildews and Mushrooms. A guide to the systematic study of the Fungi and Mycetozoa and their literature, 1–236. *Pls. 1–10.* 1889.

Corda, A. C. I. Icones Fungorum hucusque cognitorum.
1: 1–32. *Pls. 1-7.* 1837.
2: 1–43. *Pls. 8-15.* 1838.
3: 1–55. *Pls. 1-9.* 1839.
4: 1–53. *Pls. 1-10.* 1840.
5: 1–92. *Pls. 1-10.* 1842.
6: 1–91. *Pls. 1-20.* 1854. Edited by J. B. Zobel.
Standard work with illustration of thousands of fungi.

Oudemans, C. A. J. A. Révision des Champignons tant supérieurs qu' inférieurs jusqu' à ce jour trouvés dans les Pays-Bas.
1: 1–638. 1893. Hymenomycetes, Gasteromycetes, Hypodermeæ.
2: 1–491. *Pls. 1–14.* 1897. Phycomycetes and Pyrenomycetes.

Schroeter, C. Die Pilze Schlesiens. Kryptogamen-Flora von Schlesien.
3^1: 1–814. 1889.
3^2: 1–597. 1908.

Massee, George. British fungi with a chapter on Lichens. 1–551. *Colored Plates 1–40. Pls. A and B. 19 unnumbered figures.* Undated, (about 1911).

Massee, George and Ivy. Mildews, Rusts and Smuts: A synopsis of the Families Peronosporaceæ, Erysiphaceæ, Uredinaceæ and Ustilaginaceæ. 1–229. *Pls. 1–5.* 1913.

Schwarze, Carl A. The parasitic fungi of New Jersey. New Jersey Agricultural Experiment Station Bulletin 313: 1–226. *Figs. 1-1056.* 1917.
Contains beautiful illustrations of very many genera and species of parasitic fungi.

Clements, Frederic E. The Genera of Fungi. 1–227. 1909.

Davis, J. J. A Provisional list of the parasitic fungi of Wisconsin. Trans. Wisc. Acad. of Sci., Arts & Letters. **17**: 846-984. Oct. 1914.
Contains a host index for plant diseases in Wisconsin.

Farlow, W. G. and Seymour, A. B. A provisional host-index of the fungi of the United States.
Part I. Polypetalæ. 1–52, Aug. 1888.
Part II. Gamopetalæ, Apetalæ. 53–133, Sept. 1890.
Part III. Endogens, etc. 134–219, June, 1891.

Coons, G. H. A preliminary host index of the fungi of Michigan, exclusive of the Basidiomycetes, and of the plant diseases of bacterial and physiological origin. Michigan Academy of Science Report **14**: 232–276. 1912.

II. Special works for limited groups of fungi. These are to be preferred to any of the foregoing in many cases, as they often are more recent or are well illustrated or are more detailed, etc.

PHYLUM CHLOROPHYCEÆ.

Fam. Synchytriaceae.

Farlow, W. G. The Synchytria of the United States. Botanical Gazette **10.** 235–240. *Pl. 4.* 1885.

Tobler-Wolff, Gertrud. Die Synchytrien. Studien zu einer Monographie der Gattung. Archiv für Protistenkunde **28:** 143–238. *Pls. 10–13.* 1913.

CLASS PHYCOMYCETEÆ.

Order Saprolegniales.

Humphrey, J. E. The Saprolegniaceæ of the United States with notes on other species. Transactions of the American Philosophical Society **17:** 64–148. *Pls. 14–20.* 1892.

Cornu, Maxime. Monographie des Saprolégniées. Annales des Sciences Naturelles. Botanique. 5me Série. **15:** 5–198. *Pls. 1–7.* 1872.
This work is more devoted to the structure and development, only to a limited extent to the systematic discussion of this family. The second part of the paper and most of the plates have to do with the parasites of this family, mostly Chytridiaceæ.

Lindstedt, Karl. Synopsis der Saprolegniaceen. 1–70. *Pls. 1–4.* 1872.

Butler, E. J. An account of the genus Pythium and some Chytridiaceæ. Memoirs of the Department of Agriculture in India. Botanical series. **1**[5]: 1–161. *Pls. 1–10.* Feb. 1907.

Pieters, A. J. The Ferax group of the genus Saprolegnia. Mycologia **7:** 307–314. *Pl. 170.* Nov. 1915.

Petersen, Henning E. An account of Danish freshwater Phycomycetes, with biological and systematical remarks. Annales Mycologici **8:** 494–560. *Figs. 1–27.* 1910.
This has a very helpful discussion of the degenerate families and genera of this order as well as a discussion of the larger forms.

Thaxter, Roland. Observations on the genus Naegelia of Reinsch. Botanical Gazette **19:** 49–55. 1894.
New or peculiar aquatic fungi.

1. Monoblepharis Ibid. **20:** 433–440. *Pl. 29.* 1895.
2. Gonapodya Fischer and Myrioblepharis nov. gen. Ibid. **20:** 477–485. *Pl. 31.* 1895.
3. Blastocladia. Ibid. **21:** 45–52. *Pl. 3.* 1896.
4. Rhipidium, Sapromyces and Araiospora, nov. gen. Ibid. **21:** 317–331. *Pls. 21–23.* 1896.

Order Peronosporales.

Berlese, A. N. Saggio di una monografia delle Peronosporacee. Rivista di Patologia Vegetale **9:** 1–126. *Figs. 1–21.* 1902. **10:** 185–298. *Figs. 22–69.* 1904.

Berlese, A. N. Icones fungorum ad usum Sylloges Saccardianæ adcomodatæ. Phycomycetes. Fasc. I. Peronosporaceæ. 1–40. *Pls. 1–67.* 1889.

Beautifully executed illustrations of most of the species of this family.

Farlow, W. G. Enumeration of the Peronosporaceæ of the United States. Botanical Gazette **8:** 305–315, 327–337. 1883.

Additions to the Peronosporaceæ of the United States. Ibid. **9:** 37–40. 1884.

These two papers contain descriptions of every species of this order known from the United States up to the close of 1883, with full notes as to known distribution, hosts, etc.

Wilson, G. W. Studies in North American Peronosporales.

I. The genus Albugo. Bulletin of the Torrey Botanical Club **34:** 61–84. Feb., 1907.

II. Phytophthoreæ and Rhysotheceæ. Ibid. **34:** 387–416. Aug., 1907.

III. New or noteworthy species. (Species of Albugo and Peronospora) Ibid. **35:** 361–365. July, 1908.

IV. Host Index. Ibid. **35:** 543–554. Nov., 1908.

V. A Review of the genus Phytophthora. Mycologia **6:** 54–83. *Pl. 119.* Mar., 1914.

VI. Notes on Miscellaneous Species. Ibid. **6:** 192–210. *Pls. 135 and 136.* Jy., 1914.

VII. New and Noteworthy Species. Ibid. **10:** 168–169. My., 1918.

Rosenbaum, J. Studies of the genus Phytophthora. Journal of Agricultural Research **8:** 233–276. *7 pls.* Febr. 12, 1917.

Butler, E. J. and Kulkarni, G. S. Studies in Peronosporaceæ. Memoirs o. the Dept. of Agriculture in India. Botanical Series. **5:** 233–280. *Pls. 1–9.* 1913. (Phytophthora colocasiæ, Pythium debaryanum, Sclerospora graminicola, Scl. Maydis.)

Swingle, W. T. Some Peronosporaceæ in the Herbarium of the Division of Vegetable Pathology. Journ. Mycol. **7:** 109–130. 1892.

Order Mucorales.

Lendner, Alf. Les Mucorinées de la Suisse. Matériaux pour la Flore Cryptogamique Suisse. **3**[1]**:** 1–180. *Pls. 1–3. Figs. 1–59.* **1908.**

Sumstine, D. R. The North American Mucorales I. Mycologia **2:** 125–154. 1910.

Povah, A. H. W. A critical study of certain species of Mucor. Bulletin of the Torrey Botanical Club 44: 241–259, 287–312. *Pls. 17–20.* 1917.

Thaxter, Roland. New or Peculiar Zygomycetes.
I. Dispira. Botanical Gazette 20: 513–515. *Pl. 34.* 1895.
II. Syncephalastrum and Syncephalis. Ibid. 24: 1–15. *Pls. 1–2.* 1897.
III. Blakeslea, Dissophora and Haplosporangium, Nova Genera. Ibid. 58: 353–366. *Pls. 26–29.* 1914.

Vuillemin, Paul. Sur les Mortierella des groupes polycephala et nigrescens. Bulletin trimestriel de la Société Mycologique de France 34: 41-46. *Figs. 1–3.* 1918.

Dauphin, J. Contribution a l'étude des Mortiérellées. Ann. Sci. Nat. Nat. Bot. 9me Sér. 8: 1-112. *Figs. 1-45.* 1908.

Harshberger, J. W. Key for the determination of species of Mucor. A text-book of mycology and plant pathology. Appendix VI. 697–702. 1917.
A translation of the key to the species of Mucor from Lendner's work.

Order Entomophthorales.

Thaxter, Roland. The Entomophthoræ of the United States. Memoirs of the Boston Society of Natural History 4: 133-201. *Pls. 14–21.* 1888.

CLASS ASCOMYCETEÆ.

Order Laboulbeniales.

Thaxter, Roland. Contribution toward a monograph of the Laboulbeniaceæ. (Part I). Memoirs of the American Academy of Arts and Sciences 12: 195–429. *Pls. 1–26.* 1895. Part II. Ibid. 13: 219–469. *Pls. 28–71.* 1908.

Order Lecanorales (Disk Lichens).

Tuckerman, Edward. A synopsis of the North American Lichens. Part I, 1–261. 1882. Part II. 1–176. 1888.

Schneider, Albert. A guide to the study of Lichens. 1–234. 1898.

Fink, Bruce. The Lichens of Minnesota. Contributions from the United States National Museum 14: 1–269. *Pls. 1–51, Figs. 1–18.* 1910.
Most of our Michigan Lichens except a few of the more southern forms will be found here.

Hasse, Hermann E. The lichen flora of Southern California. Ibid. 17: 1–132. 1913.

Herre, Albert W. C. The lichen flora of the Santa Cruz Peninsula, California. Proceedings of the Washington Academy of Science 12: 27–269. 1910.

Wainio, E. A. Monographia Cladoniarum universalis. Act. Soc. Faun. Flor. Fenn. **4**: 1–509. 1887, **10**: 1–499. 1894; **14**: 1–268. 1897.

Stizenberger, E. Die Alectorienarten und ihre geographische Verbreitung. Annal. K. K. Hofmuseums **7**: 117–134. 1892.

Howe, R. Heber. Preliminary notes on the genus Usnea, as represented in New England. Bull. of the Torr. Bot. Club **36**: 309–327. *Pls. 21–23, Figs. A-C.* 1909.

A manual of the genus Usnea as represented in North and Middle America, north of the 15th parallel. Ibid. **37**: 1–18. *Pls. 1–7.* 1910.

Classification de la Famille des Usneaceæ d'Amérique du Nord. 1912.

American species of Alectoria occurring north of the fifteenth parallel. Mycologia **3**: 106–150. *Pls. 41–47.* 1911.

Thé genus Teloschistes in North America. Bull. Torr. Bot. Club **42**: 579–583. *Figs. 1–2.* 1915.

Order Pezizales, Helvellales, etc. ("Discomycetes").

Durand, E. J. The classification of the fleshy Pezizineæ with reference to the structural characters illustrating the bases of their division into families. Bulletin of the Torrey Botanical Club **27**: 463–495. *Pls. 27–32.* 1900.

This is a good discussion of the classification of these forms and gives a key to the genera and the families.

Seaver, F. J. The Discomycetes of Eastern Iowa. Bulletin from the Laboratories of Natural History of the State University of Iowa **5**: 230–297. *Pls. 1–25.* 1904.

A very good little paper. It includes naturally many of the species found in Michigan.

Discomycetes of North Dakota. Mycologia **1**: 104–114. 1909.

Contains a key to the orders and genera of Discomycetes and notes on the occurrence of each species.

A Preliminary Study of the Genus Lamprospora. Mycologia **6**: 5–24. *Pl. 114.* Jan., 1914.

North American Species of Aleuria and Aleurina. Mycologia **6**: 273–278. *Pls. 142–144.* Nov., 1914.

The earth inhabiting species of Ascobolus. Mycologia **8**: 93–97. *Pl. 184.* Mar., 1916.

North American Species of Ascodesmis. Mycologia **8**: 1–4. *Pl. 172.* Jan., 1916.

Bachman, Freda M. Discomycetes in the vicinity of Oxford, Ohio. Proceedings of the Ohio State Academy of Science **5**: 19–70. 1908.

Kupfer, Elsie N. Studies on Urnula and Geopyxis. Bulletin of the Torrey Botanical Club **29**: 137–144. 1902.

Hone, Daisy S. Minnesota Helvellineæ. Minn. Botanical Studies **3:** 309–321. *Pls. 48-52.* 1904.

Massee, George. A monograph of the Geoglossaceæ. Annals of Botany **11:** 225-306. *Pls. 12-13.* 1897.

Durand, E. J. The Geoglossaceæ of North America. Annalés Mycologici **6:** 387–477. *Pls. 5–22.* Oct. 1908.

A very valuable work with full descriptions of all species and illustrations of many of them.

Lloyd, C. G. The Geoglossaceæ. Mycological Writings. (Separate pagination) 1–24. *Figs. 782–807.* My., 1916.

Based largely on Durand's paper but with some modification of generic names and limits.

von Höhnel, Fr. System der Phacidiales v. H. Berichte der Deutschen Botanischen Gesellschaft 35; 416–422. 1917.

Gives a discussion and keys to families and genera of this group believed by the author to be intermediate between Pezizales and Dothideales.

See also Massee, British Fungus Flora, Vol 4, for Discomycetes. (Below, under Agaricaceæ).

Order Exoascales.

Patterson, Flora W. A study of the North American parasitic Exoasceæ. Bulletin of the Laboratory of Natural History of the University of Iowa **3:** 89–135. *Pls. 1–4.* 1895.

Atkinson, G. F. Leaf curl and plum pockets. Cornell University Experiment Station Bulletin **73:** 319–355. *Pls. 1–20.* 1894.

Sadebeck, R. Die parasitischen Exoasceen. Eine Monographie. Jahrbuch der Hamburgischen Wissenschaftlichen Anstalten **10**²: 1–110. *Pls. 1–3.* 1893.

Palm, Bj. (Scandinavian Taphrina Species). Arkiv Botanisk K. Svensk. Vet. **15:** 1–41. *9 figs.* 1917–18.

A study of the Exoascaceæ of Scandinavia with keys to all the species. Original article not seen, hence exact title not given.

Order Tuberales.

Gilkey, H. M. A revision of the Tuberales of California. Univ. of California Publications, Botany **6:** 275–356. *Pls. 26–30.* 1916.

Hesse, R. Die Hypogäen Deutschlands. Natur, und Entwicklungsgeschichte sowie Anatomie und Morphologie der in Deutschland vorkommenden Trüffeln und der diesen verwandten Organismen nebst praktischen Anleitungen bezüglich deren Gewinnung und Verwendung.

1: 1–149. *Pls. 1–13.* 1891. Hymenogastrales

2: 1–140. *Pls. 1–11.* 1894. Tuberales.

Massee, George. The structure and affinities of the British Tuberaceæ. Annals of Botany **23**: 243–263. *Pl. 17.* 1909.

Order Hypocreales.

Seaver, Fred J. Hypocreales. North American Flora **3**: 1–56. 1910.

The Hypocreales of North America.

I. Mycologia **1**: 41–76. *Pls. 4–5.* 1909.

II. Ibid. **1**: 177–207. *Pl. 13.* 1909.

III. Ibid. **2**: 48–92. *Pls. 20–21.* 1910.

IV. Ibid. **3**: 207–230. *Pls. 53–54.* 1911.

Weese, J. Beiträge zur Kenntnis der Hypocreaceen. I. Mitteilung. Sitzungsberichte der Math. Naturw. Klasse der K. Akad. d. Wissenschaften (Wien) **125**: 465–575. *Pls. 1–3, Figs. 1–15.* 1916.

Massee, George. A Revision of the genus Cordyceps. Annals of Botany **9**: 1–44. *Pls. 1–2.* 1895.

See also (below, under Sphaeriales) Ellis and Everhart, North American Pyrenomycetes and Tulasne, Selecta Fungorum Carpologia.

Order Sphaeriales (inclusive of segregates such as Fimetariales, Hemisphaeriales, Myriangiales, etc., which contain genera included in the older works in the Sphaeriales or Pyrenomycetes.)

Ellis, J. B. and Everhart, B. M. The North American Pyrenomycetes. 1–793. *Pls. 1–41.* 1892.

This work includes not only what are now known as Sphaeriales, but also the Hypocreales and Perisporiales and also the Dothideales.

Berlese, A. N. Icones Fungorum omnium hucusque cognitorum ad usum Sylloges Saccardianæ adcommodatæ. **1**: 1–243. *Pls. 1–162 and 22 genus plates.* 1894. Pyrenomycetes. Text bound separately from the plates, which were bound in two parts, respectively, genus *Plates 1-21* and *Pls. 1–76*, and *77–162*. **2**: 1–216. *Pls. 1–178, and 10 genus plates.* 1900. Pyrenomycetes, continued. Text bound separately from the plates, which are bound in two parts, respectively, *Pls. 1–89* and *90–178*, and 10 genus plates. **3**: 1–120. *Pls. 1–161.* 1905. Plates bound in separate parts, respectively *1–61* and *62–126*, and *127–161*.

Tulasne, L. et C. Selecta Fungorum Carpologia.

1: 1–242. *Pls. 1–5.* 1861. Erysiphei.

2: 1–319. *Pls. 1–34.* 1863. Xylarei, Valsei, Sphaeriei.

3: 1–221. *Pls. 1–22.* 1865. Nectriei, Phacidiei, Pezizei.

Chenantais, J. E. Études sur les Pyrénomycètes. Bulletin Trimestriel de la Société Mycologique de France **34**: 47–73, 123–136, *Figs. 1-7.* 1918. **35**: 46–98, 113–139, *Pls. 1–6 Figs. 8–25.* 1919.

Takes up many of the fundamental bases for our present classification of

this group and shows the errors. Discusses in particular the genera Nitschkea, Lophiotrema, Rosellinia, Otthia, Massarinula, Lasiosordaria, Podospora and various species of other genera.

Seaver, Fred J. Fimetariales. North American Flora **3:** 57–88. 1910. Includes Families Chætomiaceæ and Fimetariaceæ (Sordariaceæ).

Chivers, A. H. A monograph of the genera Chaetomium and Ascotricha. Memoirs of the Torrey Botanical Club **14:** 155–240 *Pls. 6–17.* 1915.

Griffith, David. The North American Sordariaceæ. Memoirs of the Torrey Botanical Club **11:** 1–134. *Pls. 1-19 Figs. 1-6,* 1901.

Seaver, Fred J. The genus Lasiosphæria. Mycologia **4:** 115–124. *Pls. 66–67.* 1912.

Shear, C. L., Stevens, N. E. and Tiller, R. J. Endothia parasitica and related species. U. S. Dept. of Agr. Bulletin **380:** 1–82. *Pls. 1–23. Figs. 1–5.* 1917.

On pages 13–22 are given descriptions of the known species of Endothia.

Hedgcock, Geo. G. Studies upon some chromogenic fungi which discolor wood. Missouri Botanical Garden Report **17:** 59–114. *Pls. 3–12.* 1906. Contains keys to species of Ceratostomella, Graphium, Hormodendron, Penicillium and Fusarium that cause staining of wood.

Some wood-staining fungi from various localities in the United States. Journal of Mycology **12:** 204–210. 1906.

Condensed descriptions of the species discussed in the foregoing paper.

Ellis, J. B. and Everhart, B. M. Synopsis of the North American species of Xylaria and Poronia. Journal of Myc. **3:** 97–102, 109–113. 1887. Synopsis of the North American species of Hypoxylon and Nummularia. Ibid. **4:** 38–44, 66–70, 85–93. 109–113, 1888. **5:** 19-23. 1889.

Ramsey, Glen B. The genus of Rosellinia in Indiana. Proc. Indiana Acad. Sci. 1914: 3-16. *Pls. 1-3.* 1914.

The following articles refer to the newly erected groups of largely tropical forms whose structure is not certainly known in all cases and whose relationship is not at all certain. The first paper below contains also a generic key to the Order Perisporiales.

Theissen, F. and Sydow, H. Synoptische Tafeln. Annales Mycologici **15:** 389–491. *Figs. 1–38.* 1917.

This paper contains keys to the families and genera of the Orders Hemisphaeriales and Myriangiales, and also of the Order Perisporiales. It is the culmination of the work reported in part in the papers immediately below.

Theissen, F. Hemisphæriales. Annales Mycologici **11:** 468–469. 1913. Contains keys to Family Hemisphæriaceæ.

Theissen, F. Ueber Membranstrukturen bei den Microthyriaceen als Grundlage für den Ausbau der Hemisphæriales. Mycologisches Centralblatt **3**: 273–286. *Pl. 1.* 1913.

Contains keys to the families of the order and to the genera of the families Microthyriaceæ and Hemisphæriaceæ.

Theissen, F. Lembosia-Studien. Ann. Myc. **11**: 425–467. *Pl. 20.* Nov. 1913.

Theissen, F. Trichopeltaceæ n. fam. Hemisphærialium. Centralblatt für Bakteriologie, II. Abteilung. **39**: 625-640. *1 pl., 7 figs.* 1914.

Theissen, F. and Sydow, H. Die Gattung Parodiella. Annales Mycologici **15**: 125–142. 1917. (Pseudosphæriaceæ).

Besides these, there have appeared by the foregoing author numerous smaller papers, preparatory, in a manner, to his monographic work. Professor von Höhnel, also, has published a vast amount of critical work on various groups, some of the papers touching this order being listed below. This list is especially fragmentary because of inaccessibility of literature on account of the War.

von Höhnel, Franz. Fragmente zur Mykologie. Attention may be called to the following papers under this title:

IV. Mitteilung. Sitzungsberichte der Math. Naturw. Klasse der K. Akademie der Wissenschaften (Wien) **116**: 615–647. 1907.
Discussion of the family Pseudosphæriaceæ.

VI. Mitteilung. Ibid. **118**: 275–452. *Pl. 1, Figs. 1-35.* 1909.
Revision of Family Myriangiaceæ and of the genus Saccardia, and of Family Cookellaceæ. Discussion of the relationship of these to the Pseudosphæriaceæ and Dothideaceæ.

X. Mitteilung. Ibid. **119**: 393-473. 1910.
Contains key to the didymosporous Microthyriaceæ.

XI. Mitteilung. Ibid. **119**: 617–679. 1910.
Key to genera of Capnodiaceæ and to those Dothideaceæ with superficial ascus stroma.

Order Dothideales.

Theissen, F. und Sydow, H. Die Dothideales. Annales Mycologici **13**: 149-746. *Pls. 1–6.* 1915.

A very fine piece of work, completely superseding all previous work on this group of plants.

Stevens, F. L. and Dalby, Nora. Some Phyllachoras from Porto Rico. Botanical Gazette **68**: 54–59. *Pls. 6–8.* 1919.

A description, with good figures, of a number of species of this genus.

Order Perisporiales.

See Theissen, F. Synoptische Tafeln, above.

Salmon, Ernest S. A monograph of the Erysiphaceæ. Memoirs of the Torrey Botanical Club 9: 1–292. *Pls. 1–9.* 1900.

Supplementary notes on the Erysiphaceæ.

Bulletin of the Torrey Botanical Club 29: 1–22, 83–108, 181–210, 302–316, 647–649, *Pls. 9–11.* 1902.

Burrill, T. J. and Earle, F. S. Parasitic Fungi of Illinois. Part II. Erysipheæ. Bulletin of the Illinois State Laboratory of Natural History 2: 387–432. *Figs. 1–8.* 1887.

Kelsey, F. D. The genus Uncinula. Oberlin College Laboratory Bulletin 7: 1–15. *10 Figs.* 1897.

Harshberger, J. W. Keys to the genera of Erysiphaceæ. A text-book of mycology and plant pathology. Appendix VIII. 721–726. 1917. Adapted from Salmon.

Theissen, F. Zur Revision der Gattung Dimerosporium. Beihefte zum Botanischen Centralblatt. 29²: 45–73. 1912.

Discusses the segregation of the genus with keys to genera and species.

Martin, George. Synopsis of the North American species of Asterina, Dimerosporium and Meliola. Journal of Mycology 1: 133–139. 145–148. 1885.

Theissen, F. Die Trichothyriazeen. Beihefte zum Botanischen Centralblatt 32²: 1–16. *Pl. 1.* 1914.

von Höhnel, Franz. Ueber die Trichothyriazeen. Berichte der Deutschen Botanischen Gesellschaft 35: 411–416. 1917.

Discussion of structure of perithecium and relationship of the family, and of the composition of the Order Perisporiales.

Stevens, F. L. The genus Meliola in Porto Rico. Illinois Biological Monographs 2: 475–554. *Pls. 1–5.* 1916.

Spegazzinian Meliola types. Botanical Gazette 64: 421–425. *Pls. 24–26.* 1917.

Illustrations of the type specimens of the species of Meliola described, mainly from Argentine, by Dr. Carlo Spegazzini.

Gaillard, Albert. Contribution a l'étude des champignons inférieurs. Famille des Perisporiacées. Le genre Meliola: anatomie, morphologie, systématique. Thèse. 1–164. *Pls. 1–24.* 1892.

Le genre Meliola. Bulletin de la Société Mycologique de France 8: 33–38, 176–186. Pls. 14–16. 1892.

A short summary of the foregoing and descriptions of additional species.

Order Saccharomycetales.

Kohl, F. G. Die Hefepilze, ihre Organisation, Physiologie, Biologie und Systematik, ihre Bedeutung als Gärungsorganismen. 1–343. *Pls. 1–8.* 1908.

CLASS TELIOSPOREÆ.

Order Ustilaginales.

Clinton, G. P. North American Ustilagineæ. Proceedings of the Boston Society of Natural History 31: 329–529. 1904.

The Ustilagineæ, or smuts, of Connecticut. Connecticut State Geological and Natural History Survey Bulletin 5: 1–45. *Figs. 1–55.* 1905.

Ustilaginales. North American Flora 7: 1–82. 1906.

McAlpine, D. The Smuts of Australia; their structure, life history, treatment and classifications. 1–285. *Pls. 1–56 and Frontispiece, Figs. 1–6.* 1910. (See also, Plowright, below.)

Order Uredinales.

Arthur, J. C. Uredinales (Gymnosporangium by F. D. Kern.) North American Flora 7: 83–268. 1907 and 1912.

Sydow, P. et H. Monographia Uredinearum.

1: 1–972. *Pls. 1–45.* 1904. The genus Puccinia.

2: 1–396. *Pls. 1–14.* 1910. The genus Uromyces.

3: 1–726. *Pls. 1–32.* 1915. Remainder of Pucciniaceæ, Melampsoraceæ, Zaghouaniaceæ, Coleosporiaceæ.

Klebahn, H. Die wirtswech selnden Rostpilze. 1–447. *Pls. 1–6.* 1904.

McAlpine, D. The Rusts of Australia; their structure, nature and classification. 1–350. *Pls. 1–55.* 1906.

Hariot, Paul. Les Urédinées (Rouilles des Plantes). Encyclopédie Scientifique. Bibliothèque de Botanique Cryptogamique. 1–392. *Figs. 1–47.* 1908.

Grove, W. B. The British Rust Fungi (Uredinales), their biology and classification. 1–412. *Figs. 1–290.* 1913.

Plowright, C. B. A monograph of the British Uredineæ and Ustilagineæ. 1–347. *Pls. 1–8. Figs. 1–13.* 1889.

Burrill, T. J. Parasitic Fungi of Illinois. Part I. Uredineæ. Bulletin of the Illinois State Laboratory of Natural History 2: 141–255. 1885.

Holway, E. W. D. North American Uredineæ. Parts I-IV, *Pls. 1–44.* 1905-1913.

Text and illustrations from microphotographs of species of Puccinia on various families of host plants.

Kern, Frank D. A biologic and taxonomic study of the genus Gymnosporangium. Bulletin of the New York Botanical Garden 7: 391–483. *Pls. 151–161.* 1911.

North American Species of Puccinia on Carex. Mycologia 8: 205–238. 1917.

Jackson, H. S. Carduaceous species of Puccinia, I. Species occurring on the tribe Vernoniæ. Botanical Gazette 65: 289–312. 1918.

Arthur, J. C. North American rose rusts. Torreya 9: 21–28. *Figs. 1–3.* 1909. Phragmidium.

Dietel, P. Ueber die Arten der Gattung Phragmidium. Hedwigia 44: 112–132, 330–346. *Pl. 4.* 1905.

Arthur, J. C. and Kern, F. D. North American species of Peridermium. Bulletin Torrey Botanical Club 33: 403–438. 1906.
North American Species of Peridermium on Pine. Mycologia 6: 109–138. 1914.

Weir, James R. and Hubert, Ernest E. Observations on forest tree rusts. Am. Journ. of Bot. 4: 327–335. *Figs. 1–2.* 1917.
Discussion of rusts of fir with other stages on ferns.

Ludwig, C. A. Notes on some North American rusts with Caeoma-like sori. Phytopathology 5: 273–281. 1915.
Gives keys for the determination of such rusts.

Rhoads, A. S., Hedgcock, G. G., Bethel, E. and Hartley, C. Host relationships of the North American rusts other than Gymnosporangium, which attack Conifers. Phytopathology 8: 309–352. 1918.
A very helpful paper for rusts on Conifers.

Olive, E. W. and Whetzel, H. H. Endophyllum-like rusts of Porto Rico. Am. Journ. of Bot. 4: 44–52. *Pls. 1–3.* 1917.

Arthur, J. C. Relationship of the genus Kuehneola. Bulletin of the Torrey Botanical Club 44: 501–511. 1912.
The Uredineae occurring upon Phragmites, Spartina, and Arundinaria in America.
Botanical Gazette 34: 1-20. *Figs. 1-4.* 1902.

Bisby, G. R. The Uredinales found upon the Onagraceae. Am. Journ. Bot. 3: 527-561. 1916.

Holway, E. W. D. North American Salvia Rusts. Journal of Mycology 11: 156-158. 1905.

Mains, E. B. Species of Melampsora occurring upon Euphorbia in North America.
Phytopathology 7: 101-105. 1917.

Rees, C. C. The rusts occurring on the genus Fritillaria. Am. Journ. Bot. 4: 268-373. *Figs. 1-3.* 1917.

Orton, C. R. North American Species of Allodus. Memoirs of the New York Botanical Garden 6: 173-208. 1916.

CLASS BASIDIOMYCETEÆ.

Sub-class Gasteromyceteæ.

Kauffman, C. H. Unreported Michigan fungi for 1907, with an outline of the Gasteromycetes of the state. Mich. Acad. Sci. **10**: 63–84. 1908. Includes a key to the genera and species.

Massee, George. A monograph of the British Gasteromycetes. Annals of Botany **4**: 1–103. *Pls. 1–4.* 1891.

Morgan, A. P. North American Fungi. The Gasteromycetes. Journal of the Cincinnati Society of Natural History. **11**: 141–149. *Pls. 2–3.* 1893. **12**: 8–22, 163–172. *Pls. 1–2.* 1890. **14**: 5–21. 141–148. *Pls. 1, 2, 5.* 1891.

Lloyd, C. G. The genera of the Gastromycetes. Mycological Writings **1**. (1898–1905). (Separate pagination.) 1–24. *Pls. 1–11.* Jan. 1902. Key to all the genera (American) and good illustrations.
The Lycoperdons of the United States. Mycological writings 2. (1905–1908). Mycological Notes No. **20**: 221–238. *Pls. 41–67.* 1905.
The genus Bovistella. Mycological Writings **2**: (1905–1908). Mycological Notes **23**: 277–287. *Pls. 86–89.* 1905.
The genus Mitremyces. Mycological Writings **2**: (1905–1908). Mycological Notes No. **30**: 238–241. *Pls 8, 9, 68, 69. Fig. 87.* 1905.
The Geasters. Mycological Writings 1. (1898–1905). Separate pagination. 1–44. *Figs. 1–80.* 1902.

Morgan, A. P. The North American Geasters. American Naturalist **18**: 963–970. *Figs. 1–12.* 1884.

Massee, George. A monograph of the genus Lycoperdon. Journal of the Royal Microscopical Society **7**: 701–727. *Pls. 12 and 13.* 1887.

Peck, Charles H. New York species of Lycoperdon. Report of the State Botanist (New York) **32**: 58–72. 1879.

Massee, George. A monograph of the genus Calostoma. Annals of Botany **2**: 25–45. *Pl. 3.* 1888.

Lloyd, C. G. The Tylostomeæ. Mycological Writings **2**: (1905–1908). Separate pagination, 1–28. *Pls. 10, 11, 20, 28, 74–85.* 1906.

White, V. S. The Tylostomaceæ of North America. Bull. Torr. Bot. Club **28**: 421–444. *Pls. 31–40.* 1901.

Lloyd, C. G. The Nidulariaceæ. Mycological Writings 2: (1905–1908). Separate pagination. 1–32. *Figs. 1–20.* 1906.

White, V. S. The Nidulariaceæ of North America. Bull. Torr. Bot. Club **29**: 251–280. *Pls. 14–18.* 1902.

Zeller, Sanford M. and Dodge, Carrol W. Rhizopogon in North America. Ann. Mo. Bot. Gard. **5**: 1–36. *Pls. 1–3.* 1918.

Gautieria in North America. Ibid. 5: 133–142. *Pl. 9.* 1918.
Arcangeliella, Gymnomyces, and Macowanites in North America. Ibid. 6: 49–59. *Figs. 1–3.* 1919.

Fischer, Ed. Untersuchungen zur vergleichenden Entwickelungsgeschichte und Systematik der Phalloiden. Denkschrift Schw. naturforsch. Gesellschaft **32:** 1–103. *Pls. 1–6.* 1890.

Lloyd, C. G. Synopsis of the known Phalloids. Mycological Writings 3: (1909–1912). Separate pagination. 1–96. *107 figs.* 1909.
For Hymenogastrales, see also (above under Tuberales) Hesse, Die Hypogäen Deutschlands.

Sub-class Hymenomyceteæ.
Family Agaricaceæ.

Atkinson, G. F. Studies of American Fungi. Mushrooms, edible, poisonous, etc., 1–275. *Pls. 1–76. Figs. 1–223.* 1900.
Has excellent keys to the genera and descriptions and illustrations of very many species.

Hard, M. E. The Mushroom, edible and otherwise, its habitat and time of growth. 1–609. *Pls. 1–66. Figs. 1–505.* 1908.
Excellent illustrations and discussions of the more common fleshy fungi, including many of the Pezizales as well as other groups.

McIlvaine. Charles. One thousand American Fungi. 1–704. Numerous (un-numbered) plates and figures. 1900.

Murrill, W. A. Agaricaceæ. North American Flora 9: 162–426. 1910–1916.
Descriptions, with full keys, all synonyms, etc., of the Tribes Chanterellae, Lactarieae and part of the white-spored Agariceae.
Agaricaceae (cont.) Ibid. 10: 1–226. 1914 and 1917.
(Volume not yet completed). So far as issued treats of the white-spored forms, the pink (red)- spored and most of the brown-spored forms.

Earle, E. S. The genera of the North American gill fungi. Bulletin of the New York Botanical Garden 5: 373–451. 1909.

Harshberger, J. W. Key to Agaricaceæ. A text-book of mycology and plant pathology. Appendix XI. 732–751. 1917. Adapted from the following.

Patterson, Flora W. and Charles, Vera K. Mushrooms and other common fungi. U. S. Dept. of Agr. Bulletin 175: 1–64. *Pls. 1–38. Fig. 1.* 1915.
Keys to and descriptions of the common edible and poisonous Agaricaceæ, fleshy Polyporaceæ, Hydnaceæ, Tremellaceæ, Clavariaceæ, and Gasteromycetes as well as a few Ascomycetes.

Fayod, V. Prodrome d'une Histoire naturelle des Agaricinées. Ann. Sci. Nat. Bot. VII. Sér. 9: 181–411. *Pls. 6 and 7.* 1889.

Bigeard, R. et Guillemin, Henri. Flore des champignons supérieurs de France les plus importants à connaitre. 1–600. *Pls. 1–56.* 1909.

Keys and specific descriptions to most of the fleshy fungi, Agaricaceæ and other fleshy Basidiomyceteæ, as well as larger fleshy Ascomyceteæ.

Cooke, M. C. Illustrations of British Fungi. (Hymenomycetes). Vols. 1 and 2, 1881–83; 3 and 4, 1884–86; 5 and 6, 1886–88; 7, 1889–90; 8, 1889–91. In all, 1198 colored plates.

Stevenson, John. Hymenomycetes Brittanici. British Fungi. (Hymenomycetes.)

1: 1–372. *Figs. 1–39.* 1886. Agaricus to Bolbitius.

2: 1–336. *Figs. 40–103.* 1886. Cortinarius to Dacrymyces.

Massee, George. British Fungus-Flora. A classified text-book of mycology.

1: 1–432. *Numerous (unnumbered) figures.* 1892.

Basidiomycetes through the purple-spored Agaricaceæ.

2: 1–460. *Numerous (unnumbered) figures.* 1893.

Agaricaceæ: Ochrosporæ, Rhodosporæ and part of Leucosporæ.

3: 1–512. *Numerous (unnumbered) figures.* 1893.

Remainder of Agaricaceæ-Leucosporæ; Hyphomycetes.

4: 1–522. *Numerous (unnumbered) figures.* 1895.

Ascomycetes.

Smith, W. G. Synopsis of the British Basidiomycetes. A descriptive catalogue of the drawings and specimens in the Department of Botany, British Museum. 1–531. *Pls. 1–5. Figs. 1–145.* 1908.

Murrill, W. A. The Agaricaceæ of the Pacific Coast.

I. Mycologia 4: 205–217. 1912. White-spored genera.

II. Ibid. 4: 231–262. 1912. White and ochre-spored genera.

III. Ibid. 4: 294–308. *Pl. 77.* 1912. Brown and black-spored genera.

The Agaricaceæ of Tropical North America.

I. Mycologia 3: 23–36. 1911. White-spored genera.

II. Ibid. 3: 79–91. 1911. White-spored genera.

III. Ibid. 3: 189–199 1911. White-spored genera.

IV. Ibid. 3: 271–282. 1911. Genera with rose-colored spores.

V. Ibid. 4: 72–83. 1912. Ochre-spored genera.

VI. Ibid. 5: 18–36. 1913 Ochre-spored genera.

VII. Ibid. 10: 5–33. 1918. Purple-brown to black-spored genera.

VIII. Ibid. 10: 62–85. 1918. Purple-brown to black-spored genera.

Kauffman, C. H. The Agaricaceæ of Michigan. Michigan Geological and Biological Survey Publication 26, Biological Series 5.

1: 1–924. *Figs. 1–4.* 1918.

2: 1–10. *Pls. 1–172.* 1918.

Very full descriptions of all species of Agaricaceæ known to occur in Michigan, and in many genera of all species recognized in Northeastern United States. Illustrated by excellent photographs.

White, Edward A. A preliminary report on the Hymeniales of Connecticut. Connecticut State Geological and Natural History Survey Bulletin **3**: 1–81. *Pls. 1–40.* 1905.

Has keys to the genera of Agaricaceæ, Polyporaceæ, Hydnaceæ, Thelephoraceæ and Clavariaceæ.

Second report on the Hymeniales of Connecticut. Ibid. **15**: 1–70. *Pls. 1–28.* 1910.

Keys to the species of Connecticut Agaricaceæ.

Stover, Wilmer G. The Agaricaceæ of Ohio. Proceedings Ohio State Academy of Science **5**: 462–577. 1912.

Clements, Frederic E. Minnesota Plant Studies IV. Minnesota Mushrooms. 1–169. *Pls. 1–2. Figs. 1–124.* 1910.

Includes the more striking and larger Agaricaceæ, fleshy Polyporaceæ and Boletaceæ, Clavariaceæ, Hydnaceæ, Lycoperdaceæ, Phallaceæ, Pezizales and Helvellales. A popular work.

Peck, Charles H. Reports of the State Botanist of New York. From 1871 up to about 1913. Descriptions of numerous species of fungi, chiefly Agarics, as well as monographs of many genera. Many colored illustrations. Among the more important are the following:

New York species of Amanita. Rept. **33**: 38–49. 1880.

New York species of Lepiota. Rept. **35**: 150–164. 1882.

New York species of Psalliota. Rept. **36**: 41–49. 1883.

New York species of Lactarius. Rept. **38**: 111–133. 1884.

New York species of Pluteus. Rept. **38**: 133–138. 1884.

New York species of Pleurotus, Claudopus and Crepidotus. **39**· 58–7[illegible]. 1885.

New York species of Clitopilus. Rept. **42**: 39–46. 1889.

New York species of Armillaria. Rept. **43**: 40–45. 1880.

New York species of Tricholoma. Rept. **44**: 38–64. 1891.

New York species of Omphalia. Rept. **45**: 32–42. 1892.

New York species of Pluteolus. Rept. **46**: 58–61. 1893.

New York species of Galera. Rept. **46**: 61–69. 1893.

New York species of Collybia. Rept. **49**: 32–55. 1896.

New York species of Flammula. Rept. **50**: 133–142. 1897.

New York species of Hygrophorus. Rept. **60**: 47–67. 1907.

New York species of Russula. Rept. **60**: 67–98. 1907.

New York species of Pholiota. Rept. **61**: 141–158. 1908.

New York species of Lentinus. Rept. **62**: 42–47. 1909.

New York species of Entoloma. Rept. **62**: 47–58. 1909.

New York species of Inocybe. Rept. **63**: 48–67. 1910.

New York species of Hebeloma. Rept. **63**: 67–77. 1910.

New York species of Hypholoma. Rept. **64**: 77–84. 1911.

New York species of Psathyra. Rept. 64: 84–86. 1911.
New York species of Clitocybe. Rept. 65: 59–89. 1912.
New York species of Laccaria. Rept. 65: 90–93. 1912.
New York species of Psilocybe. Rept. 65: 94–105. 1912.

Peck, Charles H. Cantherellus, N. Y. State Museum Bull. 2: 34–43. 1887.
Craterellus. Ibid. 2: 44–48. 1887.

Morgan, A. P. North American Agarics.—The sub-genus Amanita. Journal of Mycology 3: 25–33. 1887.

Murrill, Wm. A. The Amanitas of Eastern United States. Mycologia 5: 72–86. *Pls. 85 and 86.* 1913.
The genus Clitocybe in North America. Ibid. 7: 256–283. *Pls. 164–166.* 1915.
Mostly a list of species with synonyms and distribution, but contains a key to the genera closely related.
The genus Lepista. Ibid. 7: 105–107. 1915.

Earle, F. S. A key to the North American species of Hypholoma. Torreya 2: 22–23. 1902.
Keys to the North American species of Coprineæ. Ibid. 2: 37–40. 1902.
A key to the North American genera and species of the Hygrophoreæ. Ibid. 2: 53–54. 73–74. 1902.
A key to the North American species of Russula. Ibid. 2: 101–103, 117–119. 1902.
A key to the North American species of Lactarius. Ibid. 2: 139–141, 152–159. 1902.
A key to the North American species of Stropharia. Ibid. 3: 24–25. 1903.
A key to the North American species of Lentinus. Ibid. 3: 35–38, 58–60. 1903.
A key to the North American species of Panus. Ibid. 3: 86–87. 1903.
A key to the North American species of Pluteolus. Ibid. 3: 124–125. 1903.
A key to the North American species of Galera. Ibid. 3: 134–136. 1903.
A key to the North American species of Inocybe. Ibid. 3: 168–170. 183–184. 1903.

von Höhnel, Franz. Fragmente zur Mykologie. XIV. Mitteilung. Sitzungsberichte der Math. Naturw. Klasse der K. Akademie der Wissenschaften (Wien) 122: 255–309. *Figs. 1–7.* 1913.
XV. Mitteilung. Ibid. 123: 49–155. *Figs. 1–32.* 1914.
A review of the species of Mycena, with cystidia as a basis of classification.

Lange, Jakob E. (Studies in the Agaricaceæ of Denmark). Dansk. Bot. Arkiv 1: 1–40. *2 Pl.* 1913–15.
The genus Mycena with description of all known Danish species. Original article not seen, hence exact title not given.

Forster, Edward J. Agarics of the United States. Genus Panus. Journal of Mycology 4: 21–26. 1888.

Morgan, A. P. North American Species of Lepiota. Journal of Mycology **12:** 154–159, 195–203, 242–248. 1906. **13:** 1–18. 1907.

North American Species of Marasmius. Ibid. **11:** 201–212, 233–247. 1905. **12:** 1–9. 1906.

Descriptive synopsis of Morgan's North American species of Marasmius. Ibid. **12:** 159–162. 1906.

Species key to the foregoing article.

Maire, René. Les bases de la classification dans le genre Russula. Bulletin de la Société Mycologique de France **26:** 49–125. *Figs. 1–6.* 1910.

Macadam, Robert K. North American Agarics. Genus Russula. Journal of Mycology **5:** 58–64, 135–141. 1889.

Kauffman, C. H. Unreported Michigan Fungi for 1908, with a monograph of the Russulas of the state. Michigan Academy of Science **11:** 55–91. *Figs. 1–3.* 1909.

A key and descriptions of all known Michigan species of Russula.

Burlingham, Gertrude S. A Study of the Lactariæ of the United States. Memoirs of the Torrey Botanical Club **14:** 1–109. *Figs. 1–15.* 1908.

Kauffman, C. H. The genus Cortinarius: a preliminary study. Bull. Torr. Bot. Club **32:** 301–325. *Figs. 1–7.* 1905.

The genus Cortinarius with key to the species. Journal of Mycology **13:** 32–39. *Pls. 93–100.* 1907.

Morgan, A. P. North American Species of Agaricaceæ, Melanosporæ. Journal of Mycology **13:** 53–62, 143–153, 246–255. 1907. **14:** 27–32, 66–75. 1908.

Massee, George. A revision of the genus Coprinus. Annals of Botany **10:** 123–184. *Pls. 10–11.* 1896.

Harper, Edward T. Species of Pholiota in the region of the Great Lakes. Trans. Wisc. Acad. Sci. Arts and Letters **17:** 470–502. *Pls. 26–55.* 1913.

Species of Pholiota and Stropharia in the region of the Great Lakes. Ibid. **17:** 1011–1026. *Pls. 69–77.* 1914.

Species of Hypholoma in the region of the Great Lakes. Ibid **17:** 1142–1164. *Pls. 72–84.* 1914.

Additional species of Pholiota, Stropharia and Hypholoma in the region of the Great Lakes. Ibid **18:** 392–431. *Pls. 11–24.* 1916.

Family Polyporaceæ (and Boletaceæ).

Ames, Adeline. A consideration of structure in relation to genera of the Polyporaceæ. Annales Mycologici **11:** 211–253. *Pls. 10–13.* 1913.

Murrill, Wm. A. Polyporaceæ. North American Flora 9: 1–131. 1907–1908.

Northern Polypores. 1–64. 1914.

Covers the area of Northeastern U. S. and Canada included in the limits for Britton and Brown's Illustrated Flora.

Western Polypores. 1–36. 1915.

Covers the area of Alaska, British Columbia and the Pacific Coast States.

Southern Polypores 1–66. 1915.

Tropical Polypores 1–113. 1915.

Murrill, W. A. The Polyporaceæ of North America.

I. The genus Ganoderma. Bull. Torr. Bot. Club 29: 599–608. 1902.

II. The genus Pyropolyporus. Ibid. 30: 109–120. 1903.

III. The genus Fomes. Ibid. 30: 225–232. 1903.

IV. The genus Elfvingia. Ibid. 30: 296–301. 1903.

V. The genera Cryptoporus, Piptoporus, Scutiger and Porodiscus. Ibid. 30: 423–434. 1903.

VI. The genus Polyporus. Ibid. 31: 29–44. 1904.

VII. The genera Hexagona, Grifola, Romellia, Coltricia, and Coltriciella. Ibid. 31: 325–348. 1904.

VIII. Haplopilus, Pycnoporus and new monotypic genera. Ibid. 31: 415–428. 1904.

IX. Inonotus, Sesia and monotypic genera. Ibid. 31: 593–610. 1904.

X. Agaricus, Lenzites, Cerrena and Favolus. Ibid. 32: 83–103. 1905.

XI. A synopsis of the brown pileate species. Ibid. 32: 353–371. 1905.

XII. A synopsis of the white and bright-colored pileate species. Ibid. 32: 469–493. 1905.

XIII. The described species of Bjerkandera, Trametes, and Coriolus. Ibid. 32: 633–656. 1905.

A key to perennial Polyporaceæ of temperate North America. Torreya 4: 165–167. 1904.

A key to the stipitate Polyporaceæ of temperate North America. Ibid. 5: 28–30, 43–44. 1905.

A key to the Agariceæ of temperate North America. Ibid. 5: 213–214. 1905.

A key to the white and bright-colored sessile Polyporeæ of temperate North America. Ibid. 8: 14–16, 28–29, 130–132. 1908.

Neuman, J. J. The Polyporaceæ of Wisconsin. Wisc. Geol. and Nat. Hist. Survey Bull. 33, Scientific Ser. 10: 1–206. *Pls. 1–25.* 1914.

Overholts, L. O. The Polyporaceæ of Ohio. Annals of the Mo. Bot. Gard. 1: 81–155. March, 1914.

Kauffman, C. H. Unreported Michigan Fungi for 1910, with outline keys of the common genera of Basidiomycetes and Ascomycetes. Michigan Academy of Science Report 13: 215–249. 1911.

Keys to the genera of Agaricales and of the more common orders of Ascomyceteæ, as well as species keys for the genera of Polyporaceæ found in Michigan.

Lloyd, C. G. Synopsis of the genus Fomes. Mycological Writings **4**: 211–288. *Figs. 570–610.* January, 1915.
Synopsis of the genus Hexagona. Mycological Writings **3**: 1–46. *Figs. 279–330.* June, 1910.
Synopsis of the sections Microporus, Tabacinus and Funales of the genus Polystictus. Mycological Writings **3**: 49–70. *Figs. 336–356.* August, 1910.
Synopsis of the section Apus of the genus Polyporus. Mycological Writings **4**: 291–392. *Figs. 631–706.* June, 1915.
Synopsis of the section Ovinus of Polyporus. Mycological Writings **3**: 73–94. *Figs. 496–509.* October, 1911.
Synopsis of the stipitate Polyporoids. Mycological Writings **3**: 95–208. *Figs.* 395–500. 1912.

Atkinson, G. F. Observations on Polyporus lucidus Leys. and some of its allies from Europe and North America. Botanical Gazette **46**: 321–338. *Pl. 19. Figs. 1-5.* 1908.

Burt, Edward A. Merulius in North America. Ann. Mo. Bot. Gard. **4**: 305–362. *Pls. 20–22. Figs. 1–39.* November, 1917.
Merulius in North America. Supplementary Notes. Ibid. **6**: 143–145. 1919.

Murrill, Wm. A. Boletaceæ. North American Flora **9**: 133–161. 1910.
American Boletes. 1–40. 1914.
The Boletaceæ of North America. Mycologia **1**: 4–18, 140–160. 1909.

Peck, Charles H. Boletinus. New York State Museum Bulletin **8**: 74–80. 1889.
Boletus. Ibid. **8**: 80–150. 1889.
Strobilomyces. Ibid. **8**: 158–159. 1889.

Family Hydnaceæ.

Banker, H. J. A preliminary contribution to a knowledge of the Hydnaceæ. Bull. Torr. Bot. Club **28**: 199–222. April, 1901.
A contribution to a revision of the North American Hydnaceæ. Memoirs of the Torrey Botanical Club **12**: 99–194. 1906.
Lloyd, C. G. The genus Radulum. Mycological Writings **4**: 1–12. *Figs. 961–984.* May, 1917.

Family Clavariaceæ.

Cotton, A. D. and Wakefield, E. M. A revision of the British Clavariae. Trans. Brit. Mycolog. Soc. **6**: 164–198. 1918.

Harper, Edward T. The Clavaria fistulosa group. Mycologia **10:** 53–57. *Pls. 3–5. 1918.*

See also Bourdot et Galzin, below, under Thelephoraceæ.

Family Thelephoraceæ.

Burt, Edward A. The Thelephoraceæ of North America.

I. Thelephora. Ann. Mo. Bot. Gard. **1:** 185–228. *Pls. 4–5.* 1914.

II. Craterellus, Ibid. **1:** 327–350. *Pls. 15–17.* 1914.

III. Craterellus borealis and Cyphella. Ibid. **1:** 357–382. *Pl. 19* 1914.

IV. Exobasidium. Ibid. **2:** 627–658. *Pl. 21.* 1915.

V. Tremellodendron, Eichleriella and Sebacina. Ibid. **2:** 531–770. *Pls. 26–27. Figs. 1–7.* 1915.

VI. Hypochnus. Ibid. **3:** 203–241. *Figs. 1–30.* 1916.

VII. Septobasidium. Ibid. **3:** 319–343. *Figs. 1–14.* 1916.

VIII. Coniophora. Ibid. **4:** 237–269. *Figs. 1–19.* 1917.

IX. Aleurodiscus. Ibid. **5:** 177–203. *Figs. 1–14.* 1918.

X. Hymenochæte. Ibid. **5:** 301–372. *Pls. 16–17. Figs. 1–32.* 1918.

Burt, Edward A. Corticiums causing Pellicularia disease of the coffee plant hypochnose of Pomaceous fruits, and Rhizoctonia disease. Ibid. **5:** 119–132. *Figs. 1–3.* 1918.

Lloyd, C. G. Synopsis of the genus Cladoderris. Mycological Writings **4:** 1–12. *Figs. 520–530.* July, 1913.

Synopsis of the stipitate Stereums. Mycological Writings 14–44. *Figs. 531–564.* December, 1913.

von Höhnel, Franz und Litschauer, Viktor. Beiträge zur Kenntnis der Corticieen.

Sitzungsber. d. Math-Naturwiss. Klasse der K. Akad. d. Wissenschaften (Wien) **115:** 1549–1620. *Figs. 1–10.* 1906. **116:** 739–852. *Pls. 1–4. Figs. 1–20.* 1907. **117:** 1081–1124. *Figs. 1–10.* 1908.

Bourdot, H. et Galzin, A. Hyménomycètes de France.

I. Hétérobasidiés. Bulletin de la Société Mycologique de France **25:** 15–36. 1909.

II. Homobasidiés: Clavariés et Cyphellés. Ibid. **26:** 210–228. 1910.

III. Corticiés: Corticium, Epithele, Asterostromella. Ibid. **27:** 223–266. 1911.

IV. Corticiés: Vuilleminia, Aleurodiscus, Dendrothele, Gloeocystidium, Peniophora. Ibid. **28:** 349–409. 1912.

Gives keys to families and genera and often to species.

Family Auriculariaceæ.

Barrett, Mary F. Three common species of Auricularia. Mycologia **2:** 12–18. 1910.

See also Bourdot et Galzin, above, under Thelephoraceæ.

FUNGI IMPERFECTI.

von Höhnel, Franz. Zur Systematik der Sphaeropsideen und Melanconieen. Annales Mycologici **9**: 258–265. 1911.

Diedicke, H. Die braunsporigen Sphæropsideen. Ann. Mycol. **11**: 44–53. 1913.

A discussion of a few genera of this group.

Die Leptostromaceen. Ibid. **11**: 172–184. *Figs. 1–10.* 1913.

A discussion of some of the genera and species of this family and of the Pycnothyriaceæ segregated from it.

Ellis, J. B. and Everhart, B. The North American Phyllostictas with discriptions of the species puplished up to August, 1900. 1–79. 1900.

Anderson, P. J. Index to American species of Phyllosticta. Mycologia **11**: 66–79. 1919.

Additions to the species of Phyllosticta that have been recorded for North America since the publication of the preceding article together with a complete host index for the now known North American species.

Martin, George. The Phyllostictas of North America. Journ. Myc. **2**: 13–20, 25–27. 1886.

Grove, W. B. The British species of Phomopsis. Kew Bulletin of Miscellaneous Information, 1917: 49–73. *Pls. 1–2.* 1917.

Species placed by Saccardo in the genus Phoma. Kew Bulletin of Miscellaneous Information, 1919: 177–201. *Figs. 1–23.* 1919.

Discusses and gives descriptions of many species placed by Saccardo in Phoma but which must be transferred to other genera, e. g. Phomopsis, Dendrophoma, Dothiorella, Cytospora, Diplodia, Camerosporium, Rhabdospora, Gloeosporium, Colletotrichum, etc.

Diedicke, H. Die Gattung Phomopsis. Annales Mycologici **9**: 8–35. *Pls. 1–3.* 1911.

Besides a discussion of the known species of this genus and of the structural characters, the author gives a key distinguishing Phomopsis, Plenodomus, Dothiopsis, Sclerophoma and Sclerotiopsis.

Die Gattung Plenodomus Preuss. Ibid. **9**: 137–141. *Pl. 8.* 1911.

Dothiopsis, Sclerophoma and Sclerotiopsis. Ibid. **9**: 279–285. *Pl. 15.* 1911.

Die Gattung Asteroma. Ibid. **9**: 534–548. *Pl. 18.* 1911.

Sydow, H. und P. Scleropycnis, ein neuer Gattungstypus unter den hyalossporen Sphæropsideen. Ibid. **9**: 277–278. *Figs. 1–4.* 1911.

Diedieke, H. Myxofusicoccum. nov. gen. Sphæropsidearum. Ibid. **10**: 68–72. *Figs. 1–5.* 1912.

Die Abteilung Hyalodidymæ der Sphærioideen. Ibid. **10**: 135–152. 1912.

Davis, J. J. North American Ascochytæ. Trans. Wisc. Acad. Sci. Arts and Letters 19: 655–570. 1919.

Martin, George. Enumeration and description of the Septoriæ of North America. Journ. Myc. 3: 37–41, 49–53, 61–69, 73–82, 85–94. 1887.

Diedicke, H. Die Gattung Septoria. Ann. Myc. 10: 478–487. 1912.

Grove, W. B. The British species of Melanconium. Kew Bulletin of Miscellaneous Information 1918: 161–178. *1 Plate.* 1918.

Ellis, J. B. and Everhart, B. M. The North American species of Glœosporium Journ. Myc. 1: 109–119. 1885.

North American species of Cylindrosporium. Ibid. 1: 126-128. 1885.

Enumeration of the North American Cercosporæ. Ibid. 1: 17–24, 33–40, 49–56, 61–65. 1885.

Additions to Cercospora, Glœosporium and Cylindrosporium. Ibid. 3: 13–22. 1887.

North American species of Ramularia with descriptions of the species. Ibid. 1: 73–83. 1885.

Additions to Ramularia and Cercospora. Ibid. 4: 1–7. 1888.

Costantin, J. Les Mucédinées simples. Matériaux pour l'Histoire des Champignons. 2: 1–210. *Figi. 1–189.* 1888.

Sumstine, David R. Studies in North American Hyphomycetes. Mycologia 3: 45–56, *Pls. 37–39.* 1911. 5: 45–61. *Pls. 82–84.* 1913.

Rhinotrichum, Olpitrichum and the Tribe Oosporeæ.

Drechsler, Charles. Morphology of the genus Actinomyces. Botanical Gazette 67: 65–83, 147–168. *Pls. 2–9.* 1919.

Waksman, S. A. and Curtis, R. E. The Actinomyces of the soil. Soil Science 1: 99–134. *Pls. 1–3. Fig. 1.* 1916.

Wehmer, Carl. Die Pilzgattung Aspergillus in morphologischer, physiologischer and systematischer Beziehung unter besonderer Berücksichtigung der mitteleuropäischen Species. V. Systematik. Mem. Soc. Phys. et Hist. Nat. Genève. 33^2: 101–111. 1901.

Mangin, L. Qu'est-ce que l'Aspergillus glaucus? Étude critique et expérimentale des formes groupés sous ce nom. Ann. Sci. Nat. Bot. 9me Sér. 10: 303–371. *Figs. 1–15.* 1910.

Thom, Charles and Currie, James N. Aspergillus niger group. Journal of Agricultural Research 7: 1–15. 1916.

Thom, Charles. Cultural studies of species of Penicillium. U. S. Dept. of Agr. Bureau of Animal Industry Bulletin 118: 1-109. *Figs. 1–36.* 1910.

The Penicillium luteum-purpurogenum group. Mycologia 7: 134–142. *Fig. 1.* 1915.

Johan–Olsen Sopp, Olav. Monographie der Pilzgruppe Penicillium. Mit besonderer Berücksichtigung der in Norwegen gefundenen Arten. Videnskapselskapets Skrifter I. Mat.-Naturw. Kl. 1912^{11}: 1–208. *Pls. 1–23. Fig. 1.* 1912.

Thom. Charles and Church, Margaret B. Aspergillus fumigatus, A. nidulans, A. terreus n. sp. and their allies. Am. Journ. Bot. 5: 84–104. *Figs. 1–3.* 1918.

Harshberger, J. W. Keys for the determination of species of Aspergillus and Penicillium. A text-book of mycology and plant pathology. Appendix VII. 702–721. 1917. Adapted from Buchanan and from Thom.

Elliott, John A. Taxonomic characters of the genera Alternaria and Macrosporium. Am. Journ. of Bot. 4: 439–476. *Pls. 19–20. 9 graphs.* 1917.

Stevens, F. L. Some meliolicolous parasites from Porto Rico. Botanical Gazette 65: 227–249. *Pls. 5–6. Figs. 1–5.* 1918.
Contains keys to the Porto Rican species of Arthrobotryum and Helminthosporium that occur on Meliola.

Appel, O. und Wollenweber, H. W. Grundlagen einer Monographie der Gattung Fusarium (Link). Arbeiten. a. d. Kaiserl. Anst. f. Land-u. Forstwirtschaft 8: 1–207. *Pls. 1–3. Figs. 1–10.* 1910.
The most important work that has been issued on this difficult genus.

Wellenweber, H. W. Studies on the Fusarium problem. Phytopathology 3: 24–50. *Pl. 5. Fig. 1.* 1913.
Gives a division of the genus into sections and discusses some of the more important parasitic species.

Stevens, F. L. and Dalby, Nora E. New or noteworthy Porto Rican fungi. Mycologia 11: 4–9. *Pls. 2–3.* 1919.
Gives a generic key for the Tuberculariaceæ-Scolecosporieæ.

Hotson, J. W. Notes on bulbiferous fungi with a key to described species. Bot. Gazette 64: 265–284. *Pls. 21–23. Figs. 1–6.* 1917.
Papulospora, chiefly.

Shaw, F. J. F. and Ajrekar, S. L. The genus Rhizoctonia in India. Memoirs of the Department of Agriculture in India. Botanical Series 7: 177–194. *Pls. 1–6.* 1915.

THE EFFECT OF PARASITISM UPON THE PARASITE—A STUDY IN PHYLOGENY.

ERNST A. BESSEY.

Among Zoologists it is generally recognized that parasitism and certain types of morphological and anatomical changes go hand in hand. Thus among the Copepods and Cirripeds the mature animals in some of the parasitic species are scarcely more than sacks attached by some sort of sucking apparatus to the host and without any resemblance to the Crustaceans among which they are classified. In these animals the relationship is determined with certainty because of the fact that the larval stages are typical for the groups concerned. Among the insects, the scales show considerable degeneration. Many of the mites also show at maturity a much simplified condition.

In most of the foregoing cases there exist numerous intermediate stages between the free-living forms and the degenerate parasites. In the main, the modifications that have occurred have been in the simplification of the body structure of the mature individual. Thus extremities have been simplified or lost, the alimentary canal reduced or obliterated, the sense organs lacking or rudimentary; only the reproductive organs are well developed, often with a capacity for egg production far above that of their free-living relatives.

Let us now turn to plant parasites. The first step toward parasitism seems to be that of epiphytism, followed by partial or complete endophytism. Apparently at first there is no physiological connection between the epiphyte and its substratum. This step is found in nearly every group of chlorophyll-containing plants. In the Myxophyceae it is represented by the one-celled Chamaesiphon, which forms groups of gregarious cells on the filaments of algae. They are paralleled in the Chlorophyceae by Characium and Trentepohlia, in the Bryophyta by various Liverworts, and in the Anthophyta by many epiphytic plants such as Tillandsia, Epidendrum, etc. Such epiphytes are entirely holophytic and depend upon their hosts for nothing, or at least do not draw upon the organic contents of any living host cell. Doubtless, however, many of the epiphytic orchids and bromeliads are dependent for their mineral nutrients upon the decomposing bark to which their roots cling.

The next step seems to have been partial or total endophytism. Among the Chlorophyceae we find all grades of this, as well as in the Phaeophyceae, Rhodophyceae and other groups. Thus we have Chlorochytrium * living between the cells of Lemna or other plants, apparently receiving little from its host, but shelter and possibly such mineral salts as are present in the water

E. M. Observations on Chlorochytrium. Minn. Bot. Studies 2:195-204, *Pl. 19.* 1899.

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in the host. The presence of abundant well-developed chloroplasts insures a supply of its own organic food. But yet it seems likely that something else may be obtained from the host, for it has been noted that only those zygotes continue their development that have the fortune to find and enter the host plant. Among the Rhodophyceae, many genera are almost entirely endophytic within other Red Seaweeds, without losing their colored chloroplasts. But we note that they only occur in such habitats, a suspicious sign, and furthermore their vegetative development is almost exclusively of the simpler filamentous type, indicating perhaps that the semi-parasitic habit had at least not been favorable to the development of a more complicated or massive type of vegetative structure, such as is often found in their very near relatives.

Perhaps almost on a par with these are those Anthophyta that still possess well-developed green leaves, but which are undoubtedly at least partial parasites, such as some species of Mistletoes (Viscum or Phoradendron) and plants like Comandra, etc. These have undoubtedly the power to produce part, if not most, of their organic food in their own leaves, yet their growth and development are dependent upon their direct physical attachment to the proper host. Already the simple leaves of medium size or even small and the paler green color proclaim their fall from grace.

Apparently, however, endophytism, partial or complete, is the fatal step, for we find many plants that in other characters are closely allied to those just mentioned which have gone to the next logical step and have lost all of their own power to manufacture their organic food. Thus closely related to Chlorochytrium, we find Rhodochytrium, an endophytic alga in the United States in the tissues of Ambrosia. This plant has no chlorophyll, although it still seems to possess rudimentary plastids containing a red coloring matter, probably one of the carotins. Beyond a somewhat marked tendency toward the elongation of the plant body whereby it is able to reach more host cells, and the loss of the chlorophyll and reduction in size of the plastids, the modifications as yet are not very great. A step further and we find Synchytrium. Here even the rudimentary plastid is gone, and with it the last remnant of the carotin. These plants are obligate parasites, now intracellular, not merely intercellular. With the simple plant body to begin with, the steps downward to complete parasitism have brought few modifications. With more complex structures, however, we find that this is not the case.

The endophytic Rhodophyceae have been mentioned above. They were rather simply branched filaments with red chloroplasts containing in addition to chlorophyll and the carotin-like compounds, a violet red coloring matter phycoerythrin. A few species are known that are complete parasites. Among these *Harveyella mirabilis* is, as its name denotes, a very notable one. It consists of much branching filaments of short, slender, colorless cells which force their way between the cells of the host (also one of the Red Seaweeds) in exactly the manner of a fungus. The host cells are sometimes forced entirely

away from one another, standing apart in a manner to remind one of the algal cells within a lichen. Very striking is the enormous portion of the plant devoted to the organs of reproduction: whereas in Polysiphonia and other free-living Red Seaweeds the cystocarps and antherids occupy but a small part of the plant, in Harveyella the organs of reproduction are very large and the number of carpospores produced very great.

If we accept the frequently suggested hypothesis that the Ascomyceteae are derived from some ancestral form among the Rhodophyceae, they will be seen to have carried out the simplification of the vegetative structure and reduction in size of the cells in a manner similar to that for Harveyella, but to an even greater degree. As in Harveyella, the reproductive structures are strongly developed in most cases and occupy a large part of the plant. In this class, we can follow out further than anywhere else the ultimate fate of a group of plants that ceases to be holophytic. In some of the lichens, e. g., Collema, the sexuality is well marked, with free, non-motile, water-borne sperms as in the Florideae and a well developed trichogyne. In Collemodes, a nearly related lichen, the sperm remains permanently attached to the antherid. In other related fungi the trichogyne and antherid unite directly without the production of a separate sperm, in the Erysiphaceae the trichogyne is dispensed with and finally with the continual reduction in plant body and concomitally of the reproductive structures we find the plant reduced to a single cell and sexual reproduction to the union of two such cells to form a single ascus. This is the case in some of the yeasts. All along this line we find apogamy frequently appearing as in some lichens, some species of Pyronema, in many Sphaeriales and in the non-conjugating yeasts. At least, if it is not to be called apogamy it is the substitution of a union of other cells (or nuclei) for those that should unite in typical sexual reproduction.

It is among the Anthophyta that we find again very well marked results of parasitism. The mistletoes, such as Viscum and Phoradendron, are only partially paratsitic, inasmuch as they still possess well developed leaves containing chlorophyll. In the same family, however, occurs the genus Razoumofskya with its dwarf leafless stems almost chlorophyll-less and numerous, relatively large fruits. A large portion of the plant consists of an internal branching stem lying in the inner bark and young wood of the host tree. In some species this portion continues to live for many years after the thickening of the bark of the host has become so great as to cut off all opportunity for the formation of the external fruiting branches.

In the rather closely related Balanophoraceae the reduction of the vegetative parts is carried still further, so that the plant develops as only a mass of thin-walled paraenchyma with a few vascular bundles until sufficient food has been stored up when a fungus-like, thick stem is produced consisting of parenchyma and a few more or less circularly arranged vascular bundles. This leafless stem is surmounted by a swollen apex, covered with very numer-

ous small flowers. In the Rafflesiaceae, however, the vegetative reduction goes furthest. Here we meet with a structure comparable exactly to a fungus mycelium, viz.: a system of branched filaments of short cells which force their way among the tissues of the host just like the hyphae of a fungus. Only on the accumulation of sufficient food do these cells at one place begin to multiply to form a large mass of parenchymatous tissue, within which finally appear vascular bundles and the various structures of an immense flower, which in some species is a yard in diameter. Here the reduction of the vegetative portion is extreme and the relative importance of the reproductive portion has become very great.

What conclusions can we draw then from the foregoing as to the effect of parasitism upon the parasite? Clearly the simpler the structure to begin with, the slighter the change, beyond the loss of chlorophyll and chloroplasts. With the plants of more complicated vegetative structure two tendencies appear,—a simplification and reduction of the vegetative portions of the plant with a total suppression of all organs for photosynthesis (chloroplasts, leaves, etc.) and an emphasizing of the reproductive portions. When, however, the former tendency is carried too far, as in the yeasts, the reproductive portion has to be reduced as well.

FORMALDEHYDE INJURY TO WHEAT.

G. H. COONS AND H. H. MCKINNEY.

(Preliminary Note.)

For many years formaldehyde* has been the most commonly used chemical in seed disinfection. It has found its widest application in treating oats for smut, and its next most important utilization in wheat treatment to prevent Stinking Smut. To a limited extent, barley and rye have been treated.

Following the first preliminary experiments in the utilization of Fomaldehyde for this purpose, gradually there came a great number of empirical experiments and accordingly a vast array of formulae and rules developed. Agricultural practice settled upon a few simple methods of application and these methods have continued to be recommended without critical test for a number of years. For oats, the so-called "Sprinkling method" in which the grain is sprinkled until thoroughly wet with a solution of formaldehyde, 1 pint to 40 gallons of water, is commonly employed. After the sprinkling, the grain is covered 2 hours, spread out thinly to dry and then planted.

For wheat, the same solution is employed, but the grain is soaked in the liquid and floating smut balls and light grains are skimmed off. The period of covering, etc., is the same.

It has been found that farmers are prone to use the method recommended for oats in treating wheat. This method is obviously much more rapid than the "soak and skim" method. It would probably be as effective if the wheat were thoroughly fanned to remove smut balls.

Very early in the history of grain treatments, Clinton[1] experimented with concentrated formaldehyde in a simple experiment in which he exposed wheat to fumes from concentrated formaldehyde sprinkled upon a portion of the sample. He controlled smut in his experiment. In his discussion of the smut control problem he points out the disadvantage which arises from wetting the grain and then subsequently drying it before planting.

Bolley[2] in 1897 carried on experiments attempting to devise a method for killing smut on grain with the vapor from formaldehyde. While these experiments gave great promise, no definite practical recommendations were made.

For a number of years various "patent" smut remedies, whose active ingredient is formaldehyde, have been using a method of control in which a stronger solution of formaldehyde is employed than the ordinary one, and in which a small amount of solution is employed per bushel. R. J. Haskell[3] of Cornell University, in testing some patent preparations carried out experi-

*In this article, "formaldehyde" refers to the standard, approximately 40%, solution of formaldehyde gas in water.

[1]Clinton, G. P. Ill. Sta. Bul. 57.
[2]Bolley, H. L. N. D. Sta. Bul. 27 and 37.
[3]Haskell, R. J. Phytopathology 7: 381-383.

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ments with oats in which formaldehyde diluted in 5 parts of water was sprayed on oats followed by five hours covering. This method is manifestly a great simplification of the former one and all the disadvantage of the wet, swollen grain is obviated. When this method was used by farmers it instantly became popular.

Farmers in Kent County in Michigan in 1917 used the method advised for oats on wheat, and had marked success in stinking smut control. The attention of the writer was called to this successful application of the new, or so-called "dry method" and counts were made in Grand Rapids' fields to determine the success of the treatment. It was found that the treatment controlled stinking smut. Laboratory tests were then undertaken, using small quantities of wheat and proportionate amounts of formaldehyde. Under the conditions of the experiment, the treatment was found safe in its effect upon germination of wheat.

In a college circular, the details of this treatment were given along with directions for the standard sprinkling treatment on fanned grain. The new treatment was used quite generally by men who had treated oats by the dry method.

The planting season of 1917 was unprecedented. Following an extremely dry season which made early plowing almost out of the question, the fall started in the middle of September with a series of rainy periods which followed in close succession until about October 20th. The net result of the unfavorable weather was that planting of wheat stretched out over two or three weeks. The weather which followed was cold and disagreeable.

When the wheat came up it was found that in many cases the stand was very poor. That treatment was responsible was proved in many fields because of the poor stand of treated as compared to plantings of untreated grain. That formaldehyde could injure germination under certain conditions was evident from the 1917 experience.

Examination was made of all the cases of loss reported, and many cases poor stands were found associated with the "dry" treatment. There were some cases, also, in which similar injury was produced by the wet or "sprinkling" treatment, the greater percentage in case of the former treatment being due to the larger number of fields in which the dry method was used. Fields planted early were without exception of good stand and perfectly satisfactory. Fields planted during the cold, wet period showed injury.

The cases of injury to wheat could be grouped into two classes,—(a) those in which an over-dosage of or an over-exposure to formaldehyde had been given, and (b) those in which directions had been followed but a long period of airing was necessary because of delayed planting.

Injury of the first class is surely to be expected when farmers are handling a chemical so toxic to wheat as is formaldehyde. With the dry

method, the ease of application and the rapidity with which the adequate amount of formaldehyde is applied tempted farmers to over-dose. Applications five times the advised strength were common and invariably did damage to germination. It was a common practice to over-dose and to leave covered over night. The long period of covering as compared with the recommended 4 hours led to severe injury to germination under the weather conditions then prevailing. Many farmers left treated grain sacked, not recognizing that sacking was essentially covering. Injuries of this type which arose under conditions where directions were carefully followed were investigated and many interesting facts discovered. It was shown that with series of successive plantings, the first sown wheat would show perfect stand, while that which was planted after two or three days in sacks or in thin piles was weak, if not worthless. Wheat injured by formaldehyde produced curled, distorted, yellow, spindling sprouts, which often failed to emerge from the ground. Airing of grain did not remove the formaldehyde. Injury accompanied both wet and dry handlings of grain.

A series of laboratory tests using small quantities of wheat (pint or quart) and carefully measured amounts of formaldehyde in proportion such as were used in commercial treatments, were carried out. In general, the formaldehyde was applied by means of an atomizer whose capacity per "whiff" was calculated. The grain was exposed to the action of the formaldehyde in low glass vessels. The treated grain was covered the proper length of time and was then planted in the soil,—germination tests on blotters being found to give results not comparable with field studies.

The following conclusions were drawn from the tests:

Formaldehyde injury to wheat can readily be produced in the laboratory by increasing the amount of chemical or time of exposure. In this regard, wheat is more sensitive than either oats, barley or rye.

The standard wet treatment (1 pint to 40 gallons of water) or the new dry treatment each reduce germination slighly, but not more than 10%.

Formaldehyde does not air readily out of grain, but instead seems to persist, probably in a paraformaldehyde form, for a long time. Tests were obtained with a sensitive indicator on treated grain which had been exposed in the warm air of a laboratory for many months.

The action of this relict formaldehyde is cumulative, since the damage to germination may be from 50% to total.

The toxic action serves either to kill the embryo or to cause grave distortion. In this, sense of direction of growth is lost and the shoots turn and twist without emerging from the soil. Under cold, wet conditions very little of the formaldehyde will air from grain, due to the low vapor tension of the formaldehyde.

Damp soil is greedy for formaldehyde and readily appropriates it from grains, preventing damage. Very dry soil, on the contrary, does not take up formaldehyde.

The toxicity of pure formaldehyde and of formaldehyde diluted with from one to four parts of water is less than that diluted ten times. Toxicity increases with dilution up to approximately one part in 100 of water. From this dilution, toxicity decreases with dilution to 1-320 and 1-400, concentrations which are practically free from injurious effects if the grain is rightly handled.

The work done with this chemical has shown that our previous knowledge of its effects upon grain has been vague and founded on surmise. The full account of these experiments is being prepared for publication. The preliminary account indicates how knowledge of the properties of formaldehyde must influence our methods of using it.

PHENOL INJURY TO APPLES.

G. H. COONS AND GENEVIEVE GILLETTE.

(Preliminary Note.)

Injury to vegetation by fumes of various sorts has often been considered in the literature of plant pathology, and in its broader aspects involves great industrial operations through the effects which the smoke from the industrial plants have upon nearby vegetation.

The investigation covered by this paper concerns itself with a very restricted phase of the fume-injury problem, and is most nearly connected with the injury previously noted as coming from Tar, "Tarvia," and other coal tar products, such as are used for road building.

The literature of "Tar" injury has recently been considered by Chivers[1], and he has detailed experiments by which he was able to produce definite injury to growing plants, such as begonia, ferns, wandering-jew, and geraniums, by subjecting them in the laboratory to fumes from tarvia of various grades. Chivers mentions the deposit upon the plants of an oily, greasy film, and which was evidently associated with the injury to plants.

The attention of French investigators had been called to injuries of this type through the unthriftiness and death of trees along surfaced roads, and many articles have been written covering the subject. These are reviewed by Gatin[2] and others, and it is found that the bulk of the work presented has concerned itself with the nature of the injury, the types of lesions, the varieties injured, etc. Little attempt has been made to determine the toxic components, since all the articles considered that the constituents of coal tar were, in general, more or less injurious.

In this regard the advance made has been little greater than the early contribution of Oliver[3], who was seeking the cause of the injury produced in greenhouses by London fogs—an injury associated with fogs in London, but not found in fogs in the country. While assigning a portion of the injury to sulphite fumes, a part of the injury was believed to be caused by the tarry constituents of smoke, and as corroboratory evidence, definite injury by phenol (crystals) and other aromatic compounds to foliage was demonstrated by experiment.

The problem of fume injury has many practical bearings. A popular account of the injury to a rose fancier's choice collection through the burning of a tar roof and the damage suit resulting, as given by G. T. Moore[4], presents an interesting turn to the possibilities of injury. Similarly the many unpublished experiences in greenhouses, by use of tar paper in benches, or by

tarring posts or boards in the greenhouse, or that more elusive type of trouble which comes from painting steam pipes with certain tar-like paints, present an interesting corroboration to the fact that fumes from tar do injure vegetation.

The method of approach of the problem in this paper is different from that of the other contributions reviewed in the above cursory literature survey. The articles mentioned have been engaged in establishing the fact of injury by Tar or "Tarvia" fumes. In this paper one of the many constituents of the fumes has been tested as to its capacity for injury to plants.

Attention was first drawn to the problem through the finding of some inky-black apples in an express shipment in the fall of 1918. The very strong phenol odor gave a clue to the cause of the discoloration. It was not possible, however, to get the ordinary tests for phenol by crushing a piece of blackened apple, and then testing the expressed juice with iron salts. The textbooks point out, however, that when the dilution of the phenol is too great to secure results by color production, that the characteristic odor is sufficient.

Believing, therefore, that phenol was responsible, attempt was made with phenol fumes to reproduce the blackening. Concentrated phenol was placed in a small battery jar, and apples were exposed to the fumes over night. By morning, marked blackening was observed, not only of the skin but of the flesh beneath. The appearance reproduced exactly that of the apples showing the original injury. This preliminary test left no doubt as to the nature of the trouble in the original apples. It seemed likely that in some way, doubtless through a broken bottle of chemical in an adjacent package, the apples in the lower tier had been subjected to phenol fumes.

The many experiments performed in testing phenol will not be considered in detail, since the methods were simple and largely consisted of exposure of the fruit, placed upon supports in liter battery jars with tight fitting glass covers, to the fumes from various dilutions of phenol placed in the bottom of the battery jar. When different temperature effects were tested the ordinary laboratory incubators were utilized.

From experiments of the type indicated the following facts were established:

Blackening can be produced in from three to twelve hours by exposure of the mature fruit of apples, pears, quinces, vinifera grapes, plums, to the fumes of phenol in dilutions so low as 1 or 2%. Certain vegetables were used and and no consistent results were obtained, aside from the fact that potato sprouts blackened quickly and sharply, but no effect was seen on the skins or on the exposed flesh.

The failure to secure the ordinary tests for phenol indicated that the chemical was present in an extremely small amount, hence a series of experiments were undertaken to find the minimum of phenol that would produce blackening. Experiments were conducted with pieces of apple exposed to the fumes of phenol given off by solution of various strengths.

The dilutions used were 1 to 50, 1 to 100, 1 to 200, 1 to 500, 1 to 1000, and 1 to 2000. A test quantity of about 25 cc. of a solution was placed in 1 liter flask, and the series arranged in the laboratory so as to present uniform conditions. The results were very consistent. Blackening began with the stronger concentrations within an hour or two. The weaker solutions gave much slower response, the response being in proportion to dilution. 1-2000 solution gave no blackening, the tissues of the apple wizening before any effect was seen.

The above experiment was carried on in duplicate, half of the flasks being in dark and the other half in light. There was no noticeable difference in the two sets.

The influence of heat upon the blackening by phenol was in general to speed up the response. Apples put in the 25° or 37.5° incubator blackened more rapidly than those at room temperature, but the drying of the fruit in part compensated for the more rapid discoloration.

The volume of air in which the fumes may distribute themselves is important. A series of flasks of various sizes, 50 cc., 500, 1,000, 2,000 and 3,000 were prepared with 20 cc. of 1-50 phenol in each. Bits of apple were fastened with pins to the tight-fitting corks of the flasks. Within an hour blackening at the edge of the pieces in the smallest flask was plainly visible. In the largest flask blackening did not take place for several days. At that time the pieces in the smaller flasks (up to the liter) were jet black, while the 1,000 cc. and the 2,000 sizes had pieces which were conspicuously discolored.

To determine something of the nature of the reactions an apple was dropped in boiling water for 5 minutes so that a circular sector approximately 1 inch in diameter was killed. At the border of this spot, the tissue was somewhat discolored and the disorganization of the tissue passed from complete to partial to unnoticeable. The rest of the apple was normal. The apple was then exposed to phenol fumes and it was found that the part of the apple which was boiled gave no reaction, the "half-killed" portion gave a feeble reaction, the normal remainder blackened in the usual manner. The blackening seems to be a response of living cells.

The effect of phenol on juice squeezed from sound apples was tried, by adding various concentrations of phenol under various conditions to the cider. The general effect of phenol was to make the liquid a darker brown. This discoloration showed only at the top of the solution. It did not take place with boiled apple juice. It was absent when the uncooked juice was covered with oil. The more pulp cells the juice contained, the more the discolorations. If the juice was filtered to remove pulp cells no blackening took place. On centrifuged pulp cells the deepening of color was evident, after exposing them to strong phenol solution. The experiments with cider are very important and more work must be done along this avenue of attack.

All varieties of apples tested responded quickly. Clayton, Northern Spy, Arkansas Black, Grimes Golden, Wealthy, Maiden Blush, Hyslop Crab were used successfully. The character of the skin is very important in regulating the manifesting of the effects. A thick, corky skin like that of the potato, seems to prevent injury. When fruit is exposed to the fumes it quickly becomes coated with the only greasy material mentioned by Chivers. This is evidently phenol condensed upon the skin. It would seem that the waxy coat on the fruit was the best index of the likelihood of phenol sensitiveness.

Very young green apples did not blacken during the summer although repeatedly tested. Green apples placed alongside of more mature apples did not blacken, although the riper apples blackened slowly. The best response comes with the more mature specimens, tested in the fall and winter, but a ripened mealy apple in late spring does not respond well. The calyx end of the apple blackens first and presents the most characteristic discoloration. The waxy cuticle of the fruits seems to function to collect or condense the fumes, this part becoming greasy very quickly when exposed to strong phenol. It is surmised that the wax of the skin is important in bringing about the phenol reaction, serving as it does to collect the chemical.

The vascular system seems to respond more quickly than the pulp of the apple and colors a deeper black, the flesh taking on a brownish-black color. Flesh discoloration lags about two days behind the skin discoloration.

DISCUSSION.

This paper is a preliminary report upon the effect of phenol upon certain fruits. It is intended merely to record the results of the tests rather than to explain the mechanism of the reaction. It may be remarked that the experiments performed show that the response is that of living matter, not dead matter. The reaction is connected with living cells and is not the mere chemical effect of one substance upon another. The failure of green apples to blacken brings a problem of permeability and protoplasmic composition. The response of mature cells and the failure of the dead cells in the mellow apples to respond point to the possibility of this substance furnishing a criterion for active and for dead cells.

The minute quantities necessary for the reaction is also significant. When we consider the most unweighable deposit from a weak solution being able to blacken an entire apple and to communicate this effect from cell to cell until the entire apple is a brown-black mass with a jet black skin, it is evident that we are dealing with a substance which acts upon the enzymes. Since no tests in which specific enzymes have been isolated have as yet been made only a hypothesis can be advanced to account for the blackening. It may be that the phenol reacts with some oxydizing enzyme such as tyrosinase producing the blackening. Further work is planned to develop this particular suggestion.

LITERATURE CITED.

1. Chivers, A. H. The injurious effects of tarvia fumes on vegetation. Phytopathology 7:32-36. 1917.

2. Gatin, C. L. The tarring of roads and its effect on the neighboring vegetation. Ann. Sci. Nat. ser. 9, 15:165-252. 1912.

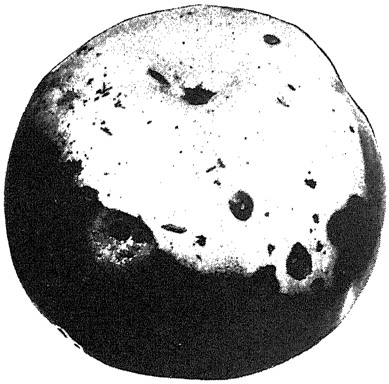
3. Oliver, F. W. On the effects of urban fog upon cultivated plants. Journ. Royal Hort. Soc. 16:1-28. 1893.

4. Moore, G. T. Roses vs. Railroads. Rhodora 5:93-96. 1903.

Michigan Agr. College.

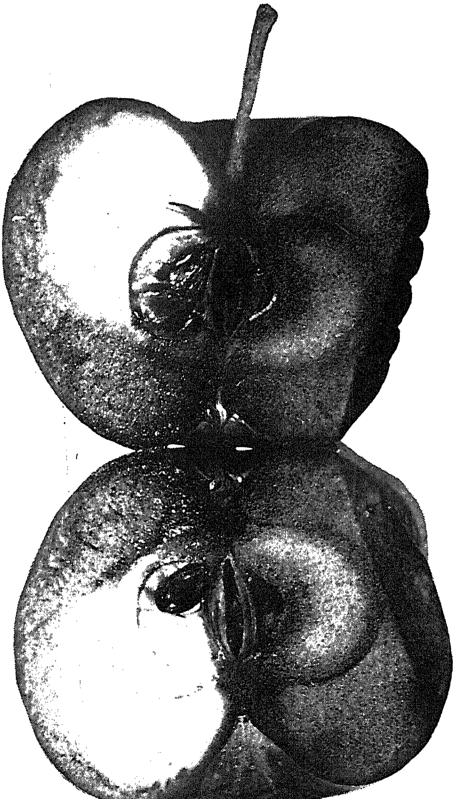
PHENOL INJURY TO APPLE.

Plate XIV. a. Stem portion exposed to fumes.
b. Apple covered with tin foil in which letters were cut.
c. The effect of phenol upon the flesh of the apple.



a

b



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THE MICHIGAN PLANT DISEASE SURVEY FOR 1918.

BY G. H. COONS.

Following the plan of other years[1] a summary of the plant disease conditions for 1918 has been prepared. This summary attempts to interpret the plant disease conditions of the year as affected by weather and to record the data of occurrence of diseases and to give estimates of the extent of losses caused.

The agencies used in this summary consist of various members of the staff of the Department of Botany, Extension Specialists of the College, and federal field agents who were assigned to Michigan for special survey work. By cooperative arrangement with the Office of Plant Disease Survey of the Department of Agriculture, Dr. E. F. Woodcock was employed to spend three months studying potato diseases as to their distribution and extent, and in particular to locate the first outbreaks of late blight, should any appear. The detailed report of this work is given by Dr. Woodcock[2] at another place in this report. I am incorporating some of Dr. Woodcock's observations on cereal diseases, etc., in this report. Similarly, by cooperative agreement with the Office of Cereal Investigations, eight field men were assigned to investigate the extent of grain diseases in Michigan fields. Work was carried into practically all the grain growing counties of Michigan. There is also included a summary of inspection reports of the Bureau of Markets, in so far as they concern themselves with carload shipments of Michigan potatoes, since these reports show the effect of plant diseases upon this important crop in relation to marketing a salable product. These reports were sent this department for "follow-up" work with shippers having trouble, through the courtesy of the Office of Cotton, Truck and Forage Crop Disease Investigations.

This report, therefore, is a compilation from the above detailed sources, and acknowledgment is made for the privilege of utilizing the data for this summary.

The Plant Disease Survey has a distinct place in the work of investigation of plant diseases in the state. It is a work of a directive nature in that it gives a picture of the happenings in the state, and serves to focus attention on the problems of most serious and pressing nature. It is important as a device for determining progress in the use of control measures. It serves to link the institution and the federal Department of Agriculture to the farm. It develops facts as to severity of disease loss which furnish concrete evidence of the losses from plant disease and the urgent need of control. In its studies on the occurrence and severity of plant disease it furnishes data which,

[1]Coons, G. H. Mich. Acad. Sci. Rept., 20:426-449. 1918.
[2]Woodcock, E. F. Mich. Acad. Sci. Rept. 21. 1919.

when compared with similar records from other states, will permit the development of generalizations as to the nature and origin of certain of our plant disease outbreaks. And lastly, it serves as an intelligence or reconnaissance bureau, which in part predicts disease outbreaks as indicated by weather conditions, and which seeks to discover these outbreaks in one part of the state or another, and give proper warning so that farmers may take necessary precautions. In these various ways the Plant Disease Survey functions to serve the people of the state. This report, which represents only incidental observations, is therefore a summary of the reports received, and an attempt at an interpretation of these reports in light of the weather conditions.

THE WEATHER OF 1918.

The weather conditions of 1918 were extremely significant in their effect on the plant disease developments. In general, the spring was exceptionally wet—rain every two or three days, delaying farm work and giving the year a lower temperature record than normal. The rainy weather persisted until about the middle of June, when dry weather began and was followed by nearly a month of drought. The weather conditions of the month may be deduced from the following table (Table 1) showing the summaries for May to October Period.

TABLE 1

Rainfall, Michigan, 1918

	May	June	July	August	Sept.	Oct.
Upper Peninsula	4.79	2.41	2.60	3.56	3.63	3.49
Northern Counties	4.74	2.46	1.43	2.76	2.17	3.47
Central Counties	3.87	2.20	1.27	1.69	2.66	3.19
Southern Counties	3.39	1.63	1.58	1.63	2.97	2.95
State averages	4.15	2.04	1.73	2.45	2.85	3.26

The interpretation of the effects of the weather can be made in general lines. The rainy season by giving so many periods for initiation of various plant diseases whose pathogens winter over on trash, fallen leaves, etc., lead to heavy primary infestation. This was quickly followed in June by severe, secondary establishment of infection so that in many diseases all the conditions for epidemics were at hand pending favorable July and August weather. As it happened, however, the July weather and that of August checked many of the disease outbreaks which had started.

Some, however, were so well established and so widely distributed that in spite of severe drought the diseases were not checked. Apple scab, for example, was present as a disease of nearly every apple leaf in unsprayed orchards,

and from these leaves as foci the disease spread to the fruit. Many sprayed orchards, because of untimeliness of spraying, obtained a poor control of scab. In a similar manner, cherry leaf spot, brown rot of plum, and wheat rust were serious diseases in a year when a glance at the weather map would indicate that diseases should be checked.

It is significant that with a wide range of diseases, the weather during the time of the establishment of the primary and secondary infections is the significant factor deciding on the severity of loss. This has already[3] been pointed out for late blight of potatoes, and is a principle of great significance on a wide range of diseases.

WEATHER INJURY TO PLANTS.

The season of 1918 was important in that it brought to the attention a few specific types of weather injury which had previously not been emphasized in the literature. In the past, a variety of serious fruit and leaf deformations have been ascribed to weather injury. All are familiar with frost effects on fruits and leaves. Similarly on forest trees, especially hard maples, a type of tip turn of the leaf has come to the laboratory every dry year. This trouble, simulating anthracnose slightly, is found in both city and forest trees alike, and has generally been assigned to physiological breakdown incident to drought conditions and lack of water. The similarity of this trouble to potato tip burn has often been postulated and it will be interesting to note if in the same way this leaf firing, long ascribed to weather, can be shown to be related to leaf hopper attack.

In early June, oats which were in extremely succulent and tender condition, were badly injured by hot, dry winds. Within a day or two the laboratory was flooded with specimens from all parts of the state, asking the cause of the new blight which came on so suddenly.

It was characteristic of the wind injury, that other grains escaped injury, with the possible exception of barley, but the oats were withered and scorched badly. The exposed leaves merely dried up. This condition was rapidly outgrown and the fields have grown and apparently suffered no loss.

Another effect of the hot, dry winds, but later in the season, was the deformation of apples. While various varieties showed the trouble, only those on exposed parts of the tree showed the injury. The effect produced by the hot winds and hot sun are shown in the picture. It will be noted that the net result was to produce girdled, conical apples. The flesh under the shrunken portion was found to be dry and cork-like.

This trouble, which is allied to "Cork"[4], was believed to be due to dryness and wind injury. The following varieties showed the injury; it is evident that stage of maturity was not especially significant in this injury, since the apples injured were of varying size and variety:

[3]Coons, G. H. Mich. Sta. Spec. Bul. 85: 10-11. 1918.
[4]Mix, A. J. N. Y. (Geneva) Sta. Bul. 426:

Hubbardstown group, Ben Davis, Northwestern and Rhode Island Greening; Red Astrican, Northern Spy.

Accounts in the trade papers indicated the same disease was present in Ohio, Pennsylvania and Virginia apples.

CEREAL DISEASES.

The work on cereal diseases was largely the result of survey work of the federal field agents assigned to Michigan. The following tables are compiled from the readings taken on the various farms visited. In nearly every county of the state, work was done and from 6 to 18 farms surveyed. The farms ran fairly typical of conditions as pictured in the country in general. The results, while not permitting an evaluation of the various counties, showed marked superiority in the counties where county agent work was carried over those in which extension work was undeveloped.

Oats: Observations on oat diseases centered on the two smuts, loose and covered. Both were found everywhere in the state and fairly uniformly distributed. The figures given in the table show the high percentage of loss from smut and the striking effectiveness of control measures where practiced by farmers. The ratio of treated to untreated fields shows the effectiveness of the control work being inaugurated by our county agents:

TABLE 2

Field Survey of Oat Smut.

Oat smut	No. of fields inspected	Average amount of smut
Treated fields	181	.25
Untreated fields	277	5.00
Total	458	

Survey carried on in 59 counties.
Of total fields surveyed 40 % (approx.) were treated.

In addition to oat smut, the following diseases were seen: Bacterial blade blight, general; Helminthosporum spot, loss, slight; "Blast", or failure of spikelets to develop, common; Stem Rust, extremely common; Leaf Rust. due to *Puccinia coronata*, common.

Barley: The acreage of barley greatly increased in Michigan during the war period. This increase was obtained as a result of planting Wisconsin seed for the most part. With the seed, naturally, the organisms causing various common barley diseases were introduced.

TABLE 3

Field Survey of Barley Diseases

Disease	Counties in which work was done	No. of fields examined	Percentage of disease found
Loose smut	59	94	1.2
Covered smut	59	94	1.8
Stripe	59	211	2.5

The extent of loss by covered smut of barley, a disease readily prevented by formaldehyde treatment, should be noted. Similarly, the high percentage of barley stripe speaks significantly of seed contamination.

During the early part of July, Dr. Woodcock visited more than fifty fields in several Michigan counties and recorded carefully the percentages of "stripe" found. His results are given here as indicative of the general run of fields found in the state:

TABLE No. 4*

Prevalence of Barley Stripe

Date	Locality	% stalks effected	Remarks
6'28'18	Ingham Co.	Absent	Oats sowed with the barley. Seed not treated.
"	" "	5 %	
"	" "	5 %	
"	" "	15 %	Red strip of 2-rowed barley on 2 sides of piece showed the 15 %; the rest of piece, a 6-rowed variety was clean.
"	" "	5 %	
"	" "	Absent	
"	" "	Absent.	
6'29'18	" "	4 %	Variety New Shube, seed originally from Europe.
"	" "	Absent	6-rowed variety.
"	" "	5 %	14 acres 6-rowed variety. Disease in both wet and dry part of field.
"	" "	Trace.	
"	" "	12 %	
"	" "	Trace.	
"	" "	12 %.	
"	" "	Absent	Oats sown with barley.
"	" "	Absent.	
"	" "	Trace.	
"	" "	5 %.	
"	" "	Absent.	
"	" "	13 %	Oderbrucker variety.
"	" "	12 %.	
"	" "	13 %.	
"	" "	18 %	Oderbrucker. A seed dealer.
7'9'18	Lenawee Co.	Trace	33 acres.
7'10'18	" "	Trace.	1 acre.
"	" "	Absent	10 acres.
"	" "	Trace	5 acres.
"	" "	Trace	10 acres.
"	" "	Trace	30 acres.
7'11'18	" "	Trace	4 acres.
7'12'18	Branch "	Trace	6 acres.
7'13'18	" "	Trace	10 acres, Wisconsin pedigree
"	" "	Absent	2-rowed variety.
"	" "	Absent.	
7'15'18	" "	4 %	5 acres, Wisconsin pedigree
"	" "	30 %	7 acres.
"	" "	Trace	4 acres.
"	" "	Trace.	
"	" "	Trace	Oats sowed with barley
7'18'18	Wayne Co.	2 %	5 acres, 6-rowed variety.
"	" "	3 %	1 acre.
7'23'18	Oakland Co.	6 %	5 acres.
8'5'18	Menominee Co.	Absent	1 acre.
8'6'18	" "	Trace	6 acres.
8'7'18	Delta Co.	Trace	1 acre.
8'9'18	Schoolcraft Co.	9 %	2 acres.
"	" "	Absent	40 acres.
8'10'18	Luce Co.	10 %	15 acres.
8'12'18	Marquette Co.	Trace	1 acre.
8'13'18	Baraga Co.	Trace	1 acre.
"	" "	Absent	2 acres,
8'14'18	" "	Trace	1 acre.
9'5'18	Ontonagon Co.	Absent	8 acres.

*In the tables given in connection with the various diseases, the word "Trace" refers to the condition where the disease was present in amounts less than 1 %.

TABLE No. 5

Summary of facts shown in Table 4

No. of counties disease present	No. of fields visited.	No. of fields in which disease was absent	No. of fields higher than 1 %	% infected fields	% clean fields	% of fields containing over 1 %
12	53	13	34	76	24	64

From the above tables it is evident that the stripe disease is widely distributed in native as well as introduced seed. It is noteworthy, however, that the disease is present in higher percentages in the various pedigreed varieties than in most of the common run of barley. It is important to note that 64% of the fields showed the disease present in percentages of more than 1%, and indeed the average infestation of fields of this class is more than 7%.

In view of the fact that this disease prevents the formation of a normal head, the percentage noted in the tables would indicate very well the actual percentage of loss to the farmer. Hence, barley stripe offers excellent opportunities for extension work and has assumed an importance even greater than the smut diseases.

Net Blotch, (*Helminthosporium teres*). This disease was of no particular consequence throughout the state and was not cutting down the yield to any appreciable extent.

Rye: Rye diseases were not found especially prevalent in 1918. The number of heads affected with ergot was extremely small in the fields where rye did not follow rye. The percentage of infection was high in the case of volunteer rye and especially high when rye grains grew in wheat fields. It was not unusual in such heads to find two-thirds of the spikelets bearing sclerotia.

TABLE No. 6

Survey of Rye Diseases

Disease	No. of counties visited	No. of fields inspected	No. of fields infested	Average percentage of disease
*Ergot (Claviceps purparea)..........	37	120	18	8 %
**Smut (Urocystis occulta)............	37	120	4	....

*One field showing 95 % of the heads affected was found—Otsego Co.
**Smut in rye was discovered in Jackson, Calhoun and Leelanau Counties varying from a trace to 25 %.

Some suggestions in explanation of this condition may be advanced. (1) The rye may have been volunteer rye and hence showed the amount of infection common to volunteer rye, since near such rye wintered sclerotia are

common. (2) The volunteer rye, being early, probably blossomed during more favorable weather conditions for infection by the spores. (3) The rye being in blossom before the wheat attracted a host of insects, this leading to heavy infection, due to transference of the Sphacelia stage of the fungus. It would seem that all of these factors are concerned with the high infestation.

An examination of the reports shows that the percentage of ergot in 1918 is less than that of 1917. During that year (1917) farmers showed much concern over this disease, and grain in the markets was docked for ergot infestation. It was then predicted (1, p. 432) that drought at heading time could effectively check the ergot, and such evidently has happened. We can then, as a result of the close observation of these two years, and the general observations of a number of years point out that the amount of rye ergot is closely connected with weather relations, and the disease increases progressively when favorable seasons come in succession. A favorable season is one in which rainy weather prevails during blossoming time, and shortly thereafter. Drought at this time can effectively prevent infection and counteract the effect of heavy infestation of seed.

Wheat Diseases: Michigan wheat fields were visited and studies made of various plant diseases doing damage. It is noteworthy that stinking smut was found in a great majority of the fields and in many cases in very high percentage. Treatment was successful in all but one case encountered in preventing loss from stinking smut. Damage to stand was reported in one or two places where errors in treatment had been made. The following table (Table 7) shows the results of the survey:

TABLE No. 7

Survey of Wheat Diseases

Disease	No. of counties visited	No. of fields visited	Average % of disease.	% of fields treated	Remarks.
Stinking smut. .	59	321	3.7	17.	Tilletia levis is common species, only one field with *T. tritici* found.
Loose smut. . . .	59	321	.29	0*	
Scab.	59	321	1.3	0*	Confined largely to southern counties.

*No seed treatment is given for Loose Smut or Scab.

The average per cent of stinking smut is lower than has commonly been estimated, since 5 and 10% has usually been suggested as the percentage occurring in Michigan fields. The figures given contain many reports on Spring Wheat which were visited too early to get the full stinking smut record. It is believed that the amount of stinking smut in Michigan fields is

higher rather than lower than the percentage given. On the other hand, it is believed that the figures for loose smut are approximately an average condition for the state, since at the time of taking records the percentage of loose smut could readily be obtained. It was noted again this year that the amount of loose smut varied with the part of the field, those parts most subjected to winter injury showing the lowest amount of loose smut. It is noteworthy also that the amount of loose smut during this season was less than that found in other years, while winter killing in fields was more pronounced. In another place[5] the writer has suggested that plants affected with loose smut are more subject to winter killing than normal plants. In no other way was the varying percentage in the same field correlated with exposed location to be explained. The correlation of the figures for the survey with the severe winter injury is also corroborative of this view. Furthermore, the comparison of Michigan losses from loose smut with that of other states, notably, Indiana, shows our loss to be as a rule only slight as compared with their 10, 15 and 20% infestations.

An interesting case was found in Muskegon County, where a field of Goens Wheat showed 5% loose smut. Red Rock nearby showed only a trace. Neither was injured by winter to any extent. Goens Wheat was a variety noted for its susceptibility in a previous publication.[5]

In a single township in Hillsdale County an excessive amount of loose smut was discovered. Careful inquiry and search failed to find any severe outbreak in any other township of the county, and survey showed 1, 2 or at most 5% in the fields.

In Reading Township, however, in one community fields showing 25, 33, 10, 10, 25%, were found. Six other farmers reported heavy loss, but figures were not obtained. In this area winter injury was not at all severe. Aside from the relation to winter injury no suggestion for the occurrence of this loose smut focus can be given.

Scab in cereals and the attending problems, corn root rot played a relatively unimportant role in Michigan in 1918. In one or two previous years wheat scab had aroused considerable concern and from 5 to 10% of the heads had been found affected, and in there the blasting affected more than an occasional spikelet, since a half or an entire head might be attacked.

It may be pointed out that Michigan systems of agriculture which make the planting of wheat after wheat or after corn very unusual are responsible in part for the low percentage of scab. In addition, favorable weather at time of heading is doubtless of prime importance. Dry conditions at this time mean little or no scab, while musty, rainy weather induces much scab.

Scab was found upon barley, rye, wheat, and quack grass this year. No disease has been found upon oats. Doubtless, the paniculate form of head favors drying and is less likely to lead to the establishment of the fungus.

[5] Coons, G. H., and Spragg, F. A. Phytopathology 8:69-70. 1918.

Alfalfa Diseases: For some years alfalfa leaf spots have been sent to the laboratory for diagnosis. Occasionally a report of severe yellowing is made. Following the discriminative work of F. R. Jones, it has been seen that both of the leaf spots of alfalfa are present in Michigan and a part of the damage previously assigned to *Pseudopeziza medicaginis* is due to the attack by *Pyrenopeziza medicaginis*. During 1918 the latter form was sent in from Van Buren and Alpena Counties. Doubtless, the distribution is much greater.

Bean Diseases: In times past bean anthracnose, bean blight and bean mosiac, in the order named, have caused damage to Michigan crops. During the summer of 1918 only one report of bean anthracnose was sent to the college. On the other hand, bean blight was reported as doing serious damage in Cass, Osceola, Huron, Midland, Van Buren, Kalamazoo, Allegan, and Isabella Counties. Doubtless the disease was found in other bean-growing counties doing some damage.

Examination of 133 samples of dry beans, some picked and others thresher run, showed only five which contained any anthracnose and the amount here was a small fraction of a percent in every case but one and this sample showed 1.4% anthracnose. Bean blight in the country was found in all but 10 samples in percentages varying from 5% to a small fraction of 1%. The average percentage in the samples such as would be used for planting was 3%.

The significance of these figures should not be overlooked. Weather conditions have served practically to eliminate bean anthracnose as a serious bean disease in Michigan, and the two years of extremely dry weather in July and August are undoubtedly responsible for this elimination. On the other hand, bean blight, which formerly was not considered a serious disease, has attracted much attention because of thhe striking examples of loss, not only in pickage but in its attack on leaves and stems. As the hot summers have served to check anthracnose, so they have served to augment the bean blight.

On lima beans the disease due to *Phyllosticta phaseolina* was seen at East Lansing as usual, and also in garden locations at Coldwater, Branch County. It was seen as a serious leaf blighting disease.

Pea Diseases: Root rot of pea was reported from Alger, Wayne, and Muskegon Counties. The bacterial leaf spot due to *Bacterium pisi* reported from Colorado was found in Michigan in various gardens. This disease has been noted for many years in Michigan and seems to be increasing. In the summary of plant disease conditions for 1916, this disease is mentioned as common about East Lansing.

Some *Alaska* seed peas were obtained from a large canning concern. The crop produced from this lot of seed showed much leaf spot due to bacteria. The same seed used the next year on ground which had never produced peas before showed a similarly high percentage of disease. By careful sorting seed

showing definite bacterial contamination was seen. It is very evident that this disease is closely allied to bean blight in its manner of attack, etc.

Various seed lots of peas, when examined in the neighboring gardens, showed widely varying amounts of the disease. It would seem that this pea disease is likely to be of great importance in the industry.

Raspberry Diseases: For some years cane blight, anthracnose, and orange rust and leaf curl have been the common diseases on Michigan plantings of raspberries and blackberries. Cane blight and anthracnose continue to be important diseases in causing loss to the crop, the cane blight apparently being the cause of the greater loss. Orange rust was found commonly on wild members of the genus Rubus. It was reported from one cultivated plantation.

Raspberry curl was reported from Hillsdale, Berry, Marquette and Ottawa Counties, doing special damage to Red Raspberries. This disease is markedly on the increase and is probably the most serious of the red raspberry diseases.

Sugar Beet Diseases: In a last year's report the occurrence of Phoma leaf spot of sugar beet was recorded. In June, 1918, numerous specimens from Midland, Ottawa, Ingham and Shiawassee Counties were sent to the laboratory. These specimens were in the seedling stage and the disease caused a "black root." Plantings gave practically pure cultures of Phoma betae. The disease was evidently seed borne, and the wet weather of early June was undoubtedly a contributing factor to the loss.

Onions: Attention was called in March, 1918, to the attack by *Botrytis allii* upon young plants developing from onion sets. Field examination showed the loss from the decaying of the bulbs to be considerable enough to produce failure in certain parts of the farm. It seemed that the bulbs were harvested when immature and unsuitable storage conditions brought about the loss.

No trace of onion smut were discovered, though search was made. *Peronospora Schleidenii* was not present so far as could be learned. Reports indicated damage in other years.

Potato Diseases: The diseases of this important crop are handled upon another page of this report in the detailed studies by Dr. Woodcock. Attention may be called to the fact that late blight did not develop in Michigan in 1918. In previous publications[3] attention has been called to the relation of weather to late blight epidemics. Wet weather in the first half of the growing season is the deciding factor influencing the late blight outbreaks. The effect of drought conditions in the early part of July in checking late blight is evident and affords the weight of another year's corroborative evidence to the conclusion previously drawn.

Through the inspectors of the U. S. Bureau of Markets, reports on Michigan cars for which inspection is requested have been made available to this office. These reports are given on the following table:

TABLE No. 8

Percentages of disease found in car-lot shipments.

Each percentage represents a car average.

Black Heart: 30, 5%.

Slimy Soft Rot (Bacterial). 6, 1½, 1, 1, 2, 5, 1, 15, 3, 5, 2, 6, 4, 2, 3, 1, 6, 2, 1, 4, 2, 7, 2, 2, 1, 9, 1½, 4, 1, 1, 2, 1, 1, 2, 2, 3, 2, 3, 1%.

Fusarium Rot: 2, 3, 5, 2, 1, 1, 1, 1, 3, 3, 3, 2, 1½, 4, 2, 1, 2½, 1, 2, 3, 4, 1, 12, 12, 7, 2, 7, 5, 5, 3, 4, 2, 2, 2, 8, 2, 3, 2½, 8, 2, 2, 1, 2, 3, 1, 2, 1, 2, 3, 1, 3, 2, 3, 4, 1, 1, 2, 8, 2, 2, 2, 4, 3, 1, 1½, 2, 1, 2, 4, 1, 3, 2, 1. 1, 11, 2, 6½, 5, 2, 50, 4, 2, 2, 2, 10, 2, 3, 3, 8, 1%

Scab: 5, 7, 5, 1, 3, 2, 2, 2, 5, 2, 4, 3, 12, 3, 9, 1, 2, 2, 20, 10, 5, 11, 4, 10, 4, 7, 5, 9, 30, 11, 2, 9, 2, 3, 5, 50%

Hollow Rot: 12, 13, 3, 15, 10, 7, 6, 70, 9, 7, 18, 6, 4. 5, 7½, 6, 5, 2, 9, 15, 4, 1, 1, 8, 1, 3, 3, 3%.

Second Growth: 16, 26, 45, 15%.

Frost Injury: 10, 9, 7, 4, 1, 20, 40, 7, 3, 3, 14, 12%.

Cuts: 20, 2, 9, 5, 8, 7, 10, 13, 3, 12, 11, 15, 11, 9. 5, 6, 3, 4, 5, 15, 8, 6, 35, 8, 6, 7, 10,5, 11, 8, 6, 12, 10, 8, 5, 14, 14, 20, 15, 6%.

Total cars examined=200.

A consideration of this table shows that black heart may occur in rather high percentage occasionally. Michigan cars frequently travel under heated service and black heart may very likely be of more importance than the figures show.

The slimy soft rot of potatoes, commonly assigned to *Bacillus carotovorous*, probably is not a clearly defined group. While the true soft rot organism can rot potatoes weakly, it is of comparatively rare occurrence according to the writer's observation. Many other organisms that commonly are found upon the potato in nature cause soft rotting when potatoes are put under humid conditions.

Many forms of Fusarium decay under very moist conditions simulate bacterial decay. The breakdown following frost injury similarly may be confused with a true disease inaugurated by bacteria.

The loss by Fusarium rot is the most striking thing in the table. 93 of the 200 cars reported showed more or less loss from this source. The potatoes that rot in this way are the mishandled, bruised, or cut potatoes, whose broken skins admit the decay organisms. The loss caused in this way is a commentary upon the careless handling methods in vogue in marketing potato tubers.

Potato scab was frequently found in appreciable amounts, although all potatoes inspected were of the U. S. Government No. 1 grade, and presumably had undergone some sorting. 36 of the 200 cars showed loss from this source.

Many tubers showed hollow heart and this cleavage of the flesh, usually confined to the large potatoes, was a serious disadvantage in selling the crop. The second growth potatoes and the frost injury are intimately connected with points made concerning Fusarium rot and the means of combatting it. The rather high percentage of cuts and bruises is important since these potatoes are the ones which are sure at some time to develop Fusarium attack.

SUMMARY.

The extent of certain important Michigan crop losses due to diseases so far as the records of the department show are here recorded. It is evident from the foregoing brief account that plant diseases are an extremely important factor in food production.

Plate XV. Effect of hot winds upon apple.

NOTES ON THE MICHIGAN FLORA. II.

OLIVER ATKINS FARWELL.

In the Michigan Flora[1] the enumeration begins with the Ophioglossaceae, presumably under the supposition that this family is the most primitive of the Filicales. In these notes the order of genera is that of Gray's Manual, ed. 7.

POLYPODIACEAE.

Phegopteris Robertiana (Hoffm.) A. Br. is to be looked for in Michigan as its range crosses the state.

Allosorus and Cheilanthes were published in the same year, the former appearing first. It was based on the "Adianta spuria" of Swartz, some nine species, eight of which were included in Cheilanthes by Swartz, who referred Allosorus as a synonym to his Cehilanthes. Since Allosorus was based not on one species but on all the "Adianta spuria" (nine species) of Swartz, the name must therefore be retained for that group containing the larger number of species which are congeneric. Also according to the Vienna Code, Article 45, "If . . . . one of the parts detached contains a great many more species than the others, the name is reserved for that part of it." Of the nine species on which Bernhardi founded Allosorus, Swartz referred eight to his Cheilanthes, creating a new genus, Mohria, for the other. The majority of the species on which Bernhardi founded Allosorus are unquestionaly congeneric with those species on which Swartz founded his Cheilanthes and the two generic names are synonymous. Art. 46, "When two or more groups of the same nature are united, the name of the oldest is retained." As Allosorus is older than Cheilanthes the latter must give way to the former. This may be deplorable, but no other conclusion can be arrived at under the Vienna Rules.

ALLOSORUS LANOSA (Mx.) n. comb. (*Nephrodium lanosum* Mx. Fl. Bor. Am., 270, 1803). The range of this species crosses Michigan; it should be looked for in the rocky sections of the Upper Peninsula.

I have been informed by Dr. H. T. Darlington of the Michigan Agricultural College that the specimens of *Pellaea atropurpurea* (L.) Link from Michigan have a glabrous rhachis and rachiola which proves our plant to be *P. glabella* Mett.

[1]Beal, W. J., Michigan Flora. A list of the Ferns and Seed Plants growing without cultivation. (Reprinted from Fifth Report of the Michigan Academy of Science, 1904.) Lansing, 1904.

[1]In the region of Gray's Manual there are three other species of the genus. These are *Allosorus Alabamensis* (Buckley) O. K.; *Allosorus tomentosus* (Link) n. comb. (*Cheilanthes tomentosa* Link, Hort. Berol. 2, 42, 1833); *Allosorus gracilis* (Fee) n. comb. (*Myriopteris gracilis* Fee, Gen. Fil. 150, 1850-2). The earlier *A. gracilis* of Presl. is a synonym of *Cryptogramma Stelleri* (Gmel.) Prantl. and cannot interfere with the use of the name "gracilis" for this species.

Asplenium viride Huds. should be looked for in the lime-stone regions of the Upper Peninsula.

The proper authority for the combination *A. Filix-femina* var. *Michauxii* (Spreng.) is Clute.

Woodsia scopulina D. C. Eaton of Michigan and Minnesota has been described as a new species, *W. Cathcartiana Robinson;* the former name should therefore disappear from the Michigan Flora. *W. glabella* R. Br. should be looked for along the shores of Lake Superior.

Pteretis is the oldest name for the Ostrich Fern, as shown by Dr. Nieuwland. Our plant is not exactly identical with the European type. It has been described as a distinct species and as a variety. The differences, however, are scarcely of specific value and it may better be considered as a good geographical variety. It may be known as PTERETIS STRUTHIOPTERIS (L.) Nieuwl. var. PENNSYLVANICA (*Willd.*) n. comb. (*Struthiopteris Pennsylvanica* Willd. Sp. Pl. V. 289, 1810).

Osmunda cinnamomea L. var. *frondosa Gray.* This rare form with some of the fertile fronds partly sterile below was found at Port Huron, June 23, 1918. No. 4,960.

Osmunda regalis L. var. *spectabilis* (Willd.) Milde. The specific type has green fronds at all times and the pinnules are abruptly narrowed just above the broad base, thence gradually tapering to an apex. I have not found anything answering to this form. Our plant is purplish when young, often glaucous on the stipes and the pinnules are not contracted just above the base. It answers to Willdenow's *O. spectabilis* and is a good geographical variety.

OPHIOGLOSSACEAE.

The plant listed as *Botrychium boreale* (Fries) Milde is a form of *B. Matricariaefolium* R. Br.

EQUISETACEAE.

The evergreen species of Equisetum (Tourn.) L. have been taken out of that genus and now constitute the genus Hippochaete Milde. For species and varieties see *Memoirs New York Botanical Garden*, Vol. 6, pages 461-72, and *American Fern Journal*, Vol. 7. pages 73-6, 1917. *H. prealta* var. *intermedia* was collected near Port Huron, June 23, 1918, No. 4,962. *H. Nelsoni* was collected in Lenawee County, in 1917, by Mr. Cecil Billington.

SELAGINELLACEAE.

Fernald has shown that "apus" is not the Linnaean specific apellation for our slender, creeping species. The proper binomial is *Selaginella apodum* (L.) Fernald.

PINACEAE.

P. Banksiana Lamb. is the proper designation for the Jack Pine.

Two species, the White spruce, *Picea Canadensis* (Mill.) B. S. P. and the Hemlock Spruce, *Tsuga Canadensis* (L.) Carr. derive their specific names from the same source—the *Pinus Canadensis* L. It is true that "(Mill.)" is quoted as the original author of the specific name of the former, but this is an error, as Miller took his specific name and technical description bodily from Linnaeus. One or the other must drop the specific name Canadensis, as the specific name can apply to but one element of the aggregate when it is segregated. The White Spruce is *Picea Canadensis* (L.) B. S. P.; the Hemlock Spruce is *Tusga Americana* (Mill.) Farwell. See *Bul. Tor. Bot.* Cl. Vol. 41, page 621, 1914, and *Rhodora*, Vol. 17, pages 164-8, 1917.

Juniperus Virginiana L. On the rocky shores of Keweenaw Point, many years ago, I collected specimens of a prostrate Juniper, creeping or trailing over rocks, with the habit of *J. horizontalis;* the leaves and fruit on erect peduncles proved it to be *J. Virginiana* L. I have not seen the trailing form since that time.

Juniperus Sabina L. The American Savin is now generally considered to be a distinct species from the European and should be known as *J. horizontalis* Moench.

TYPHACEAE.

Typha latifolia L. The common Cat-tail is found throughout the state along the borders of streams and ponds. The typical form has both the staminate and pistillate spikes of about equal length and without any space between them. A form with the spikes about 3 centimeters apart is var. *ambigua* Sond. Shores of Belle Isle, Aug. 11, 1893; No. 353b. Another form with the spikes slightly separated and the staminate spike longer than the pistillate is the var. *remotiuscula* Simonkai. Keweenaw Co., September 4, 1885, No. 353; Ypsilanti, June 21, 1892, No. 383a.

Typha angustifolia, L. The narrow-leaved Cat-tail is usually said to be rare inland. I have seen acres of it in marsh lands in the vicinity of Wind Mill Point at the head of Detroit River, Sept. 19, 1901, No. 1,761; Oakwood, Sept. 23, 1915, No. 4,108; Junior, July 13, 1918, No. 5,076.

SPARGANIACEAE.

Sparganium simplex var. angustifolium is now considered as specifically distinct and should be known as *S. angustifolium* Mx.

FLUVIALACEAE.

Potamogeton diversifolius Raf. of the Michigan Flora, should become *P. hybridus* Mx.

Potamogeton filiformis Pers. should become *P. marinus* L. Among many modern botanists there has sprung up a very disconcerting practice, and a needless one as well, of replacing old and well known names by those of a later date, because, forsooth, the authors are not able to interpret to their own satisfaction the older descriptions; hence the name is set aside as a "confusing" name. There would be much less "confusion" if old names were not discarded unless it could be proved beyond a shadow of doubt to what species they do belong; this can not be done. To retain the old name, therefore, for the species for which it had stood unchallenged for perhaps a century and a half, more or less, would be not only the better plan but much less "confusing."

Potamogeton interruptus Kit. should be dropped as it has been shown by Mr. St. John that this species if distinct from *P. pectinatus* L., does not occur in this country.

P. lonchites Tuckerman becomes *P. Americanus* C. & S.

P. Nuttallii Cham. and Sch. becomes *P. epihydrus* Raf.

P. spathulaeformis (Robbins) Morong. becomes *P. spathaeformis* Tuckerman.

P. Spirillus Tuckerman becomes *P. dimorphus* Raf.

P. Zizii Roth becomes *P. angustifolius* Berch. & Presl.

P. zosteraefolius Schum. becomes *P. compressus* L.

P. Friesii Ruprecht becomes *P. mucronatus* Schrad.

Other species and varieties credited to Michigan are the following:

P. epihydrus var. *Cayugensis* (Wieg.) Benn.

P. Americanus var. *Novaeboracensis* (Morong.) Benn.

P. bupleuroides Fernald.

P. strictifolius Benn.

P. rutilus Wolfg. In various slips at Detroit June 29, 1900, No. 1,636a.

NAJADACEAE.

Najas flexilis (Willd.) Rost. & Schm. var. CONGESTA n. var. Stems short, much branched, and forming a dense, more or less globular mass, like a small pin cushion, 1-3 inches in diameter. Detroit R.; Sept. 23, 1892, No. 1,312b.

"Naias" should be spelled with a "j", not with an "i".

JUNCAGINACEAE.

Scheuchzeriaceae should become Juncaginaceae.

ALISMOIDACEAE.

Alismaceae should become Alismoidaceae.

Sagittaria sagittaefolia L. becomes *S. latifolia Willd.*; the forma *angustifolia* becomes *S. latifolia f. gracilis* (Pursh.) Robinson; the other forms enumerated remain but the authority for them under *S. latifolia* is Robinson

instead of Britton. *S. rigida* Pursh becomes *S. heterophylla* Pursh with vars. *elliptica* Engelm; *rigida* (Pursh) Engelm; and *angustifolia* Engelm.

Echinodorus tenellus (Mart.) Buch. This is no longer considered to be a species of Alisma.

A. Plantago-aquatica L. is not found in America; there is a variety *Americana* R. & S. and a variety *parviflora* (Pursh) Farwell. Both are found in Michigan.

HYDROCHARIDACEAE.

Valisneriaceae becomes Hydrocharidaceae.

Philotria Raf. becomes Elodea Mx.

P. Canadensis (Mx.) Britton becomes *E. Canadensis* Mx.

GRAMINACEAE.

Gramineae becomes Graminaceae.

Zea Mays L. Corn, Maize. Adventitious.

Andropogon scoparius Mx. var. *frequens Hubb.* replaces *Andropogon scoparius* Mx.

Sorghastrum nutans (L.) Nash should replace *S. avenaceum* (Mx.) Nash.

Syntherisma Walt. becomes Digitaria Heist.

S. linearis (Krock) Nash. becomes *D. linearis* (L.) Pers.

S. sanguinalis (L.) Dulac. becomes *D. sanguinalis* (L.) Scop.

D. filiformis (L.) Koeler is credited to Mich. in Gray's Manual.

Echinochloa Crusgalli (L.) Beauv. Greenish or yellowish with awns up to about 2 cm. in length. Keweenaw Co., No. 648, Aug. 8, 1888; Detroit, No. 648b, July 21, 1892.

E. CRUSGALLI forma MITIS (Pursh) n. comb. (*Panicum Crusgalli* var. *mite* Pursh. Fl. Am. Sept. 1, 66, 1814). Most of the flowers are muticous, not awned. Detroit, Aug. 18, 1893, No. 648a; Orion, Aug. 29, 1895, No. 648c; Marquette, Aug. 1902, No. 648d.

E. CRUSGALLI forma PURPUREA (Pursh) n. comb. (*Panicum Crusgalli* var. *purpureum* Pursh. Fl. Amer. Sept. 1, 66, 1914.) Panicles purplish, flowers muticus to acuminate, the acumination about as long as the floret. Detroit, Oct. 2, 1900, No. 1701.

E. Crusgalli (L.) Beauv. forma SABULONUM n. f. (*Panicum Crusgalli* var. *sabulonum* Trin. Gram. 2, pl. 163, 1829). Panicle pyramidal, lower branches elongated (10 cm. long), with secondary branchlets 2-3 cm. in length, awns 3 cm. long, purplish and hispid. Detroit, Oct. 2, 1900, No. 1701½.

E. Crusgalli (L.) Beauv. forma *longiseta* n. f. (*Panicum Crusgalli* var. *longisetum* Trin. Gram. 2, pl. 162, 1829?). Similar to the species but awns

about twice as long (up to 5 cm.) and more or less purplish; bulbous bases of hairs slightly larger and more numerous: appearing as if indigenous. Marshy borders of Belle Isle, Sept. 23. 1904. No. 1887.

E. CRUSGALLI var. MURICATA (Mx.) n. comb. (*Panicum muricatum* Mx. Fl. Bor. Am. I. 47. 1803; *E. muricata* (Mx.) Fernald). This variety is rare compared with the preceding. The rigid hairs and their bulbous bases are conspicuous and give to the spikelets somewhat the appearance of a Cenchrus. Detroit. Aug. 13, 1902, No. 1782.

Conchrus tribuloides L. In Belle Isle, June 24, 1905, No. 1919. Rare, The note under this name in the Michigan Flora refers entirely to *Cenchrus Carolinianus* Walt. which is very common.

SAVASTANA ODORATA var. FRAGRANS (Willd.) n. comb. (*Holcus fragrans* Willd. Sp. Pl. IV. 936, 1805). The plant in Michigan apparently is not exactly identical with the species; the above name should be adopted. Keweenaw Co., Aug. 21, 1890, No. 801; Rochester, May 23, 1910, No. 801a; Parkedale, May 19, 1912, No. 2555.

Anthoxanthum odoratum L. has been collected near Palmer Park by Mr. C. Billington.

Oryzopsis pungens (Torr.) Hitch. should replace the name *O. juncea* (Mx.) B. S. P. Bluffs in Keweenaw Co., May 30, 1884, No. 214.

O. racemosa (J. E. Sm.) Ricker should replace the name *O. melanocarpa* Muhl. Rochester, May 12, 1909, No. 2073.

Alopecurus aristulatus Mx. should replace A. *geniculatus* L. Belle Isle. June 4, 1895, No. 972; Detroit, June 17, 1911. No. 214a; Port Huron, June 23, 1918, No. 4969.

Sporobolus brevifolius (Nutt) Nash. should be transferred to Muhlenbergia where it becomes *M. cuspidata* (Torr.) Rydb. Keweenaw Co., June 27, 1895, No. 848; and *Muhlenbergia squarrosa* (Trin.) Rydb. Keweenaw Co., July 1, 1895, No. 849½.

Sporobolus serotinus (Torr.) Gray should be replaced by *S. uniflorus* (Muhl) Scribn. & Merr. Keweenaw Co., Aug. 15, 1887, No. 526, and Aug. 20, 1887, No. 526a.

Agrostis stolonifera L. (*A. vulgaris* With). In the Species Plantarum p. 62, 1753, Linnaeus, under this name, combined the two species later known as *A. vulgaris* With. and *A. verticillata* Vill. Two years later in 1755 in the Flora Suecica, page 22, he used the same name and description for a plant that was common in Sweden, thus himself fixing the type of his *A. stolonifera*. As *A. verticillata* was not known to occur in Sweden at that time, the name must

perforce be construed as applying to the *A. vulgaris* which was common there. The panicle is slightly purplish and minutely rougish. Keweenaw Co., July 5, 1895, No. 856; Belle Isle, July 21, 1895, No. 856a.

A. STOLONIFERA forma HISPIDA (Willd.) n. comb. (*A. hispida* Willd. Sp. Pl. 1,370, 1797). Panicle long hispid. Keweenaw Co., July 5, 1895, No. 856⅛.

A. STOLONIFERA var. PALUSTRIS (Huds.) n. comb. (*A. polymorpha* var. *palustris* Huds. Fl. Ang. 32, 1798; *A. alba* Lin. Sp. Pl. 63, 1753). Plants low, panicles short and pale (not violet). Keweenaw Co., July 5, 1895, No. 856½; Ypsilanti, June 30, 1892, No. 560a and No. 1,251½; Detroit, July 23, 1902, No. 1780; Parkedale, July 23, 1912, No. 2853; Belle Isle, Aug. 29, 1903, No. 1811.

A. STOLONFERA var. PALUSTRIS forma DECUMBENS (Gaud.) n. comb. (*A. diffusa* Host. Gram. Austr. IV. t. 55. 1809; *A. alba* var. *decumbens* Gaud. Fl. Hel. I. 188, 1828). Panicle violet colored. Keweenaw Co., Aug. 26, 1887, No. 560; Algonac, July 7, 1812, No. 2829. *A. stolonifera* var. *minor* (Vasey) Farwell belongs here. The plant was determined by Dr. Vasey as his *A. alba.* var. *minor.* It is low with a very narrowly oblong panicle. Keweenaw Co., Aug. 29. 1887, No. 571.

A. STOLONIFERA var. MAJOR (Gaud.) n. comb. *A. alba.* var. *major* Gaud. Fl. Helv. 1,189, 1828; *A. gigantea* Gaud. Agrost. I, 81, 1811.) A tall form with elongated panicles and broader leaves. Belle Isle, July 2, 1901, No. 1719.

A. stolonifera var. *coarctata* (Ehrh.) Pers. (*A. stolonifera* var. *maritima* (Lam.) Koch; *A. alba* var. *coarctata* (Ehrh.) Blytt.) Plant gray-green, stems prostrate and rooting at the joints, flowering branches erect, tufted or cespitose, panicle pale, contracted. Detroit, June 27, 1893, No. 560 b; Belle Isle, July 22, 1893, No. 560 c; Algonac, July 7, 1912, No. 2828. In the last edition of Gray's Manual the varietal name "maritima" is used for this plant, but the use of "coarctata" as a varietal name dates from Persoon, 1805, and antedates that of the other by 31 years.

A. stolonifera var. *stolonifera* (Sm.) Koch. (*A. stolonifera* var. *prorepens* Koch; *A. alba* var. *prorepens* Asch.; *A. alba* var. *stolonifera* G. F. W. Mey.) Similar to the last preceding but plant grass-green, more widely creeping and less tufted, flowering branches reclining or weakly ascending, not erect. Rochester, July 4, 1901, No. 560 d; Parkdale, July 4, 1918, No. 5032. The var. *coarctata* generally grows in rather dry places, while the var. *stolonifera* is usually found on wet grounds.

The above interpretation should replace *A. alba* and its var. *stolonifera* and *A. coarctata* of the Michigan Flora.

Calamagrostis confinis of the Michigan Flora becomes *C. inexpansa* A. Gr.

C. hyperborea Lange should be looked for along the south shore of Lake Superior as it is known to occur in Minnesota and Northern Vermont.

C. Pickeringii var. *lacustris* (Kearney) Hitch. ranges along the Great Lakes and probably occurs in Michigan.

Holcus Authors not L. becomes Ginania Bub. *G. lanatus* (L.) Hubb. Velvet Grass. Detroit, August, 1908, No. 2062.

Eatonia Authors not Raf. becomes Reboulea Kunth. *R. obtusata* var. *lobata* (Lin.) O. A. F. doubtless occurs in Michigan as according to Gray's Manual it is the commonest form of the species in the north.

Trisetum subspicatum becomes *T. spicatum* (L.) Richter. Plants answering to the European type were collected at Lake Linden, Keweenaw Peninsula, in August, 1904, No. 1825½. A very rare species here, the common form being the var. *molle* (Mx.) Piper[1]; frequent along the rocky shores of the Peninsula, No. 658, August 16, 1888.

Avena sativa L. An escape from cultivation is to be found throughout the State, as are all the cultivated grains. They are all found with sufficient frequency to be listed as adventitious. Keweenaw county, August 15, 1888, No. 528; Ypsilanti, June 30, 1892, No. 528a; Belle Isle, August 26, 1892, No. 528b.

Spartina cynosuroides of the Michigan Flora becomes S. Michauxiana Hitchc. The common form of this species in Michigan is a plant with a panicle about a foot long, with numerous short spikes, three inches or less in length on short peduncles ½-¾ of an inch long, lemmas 2 toothed. River Rouge, September 15, 1918, No. 5134, and September 30, 1915, No. 4119; Belle Isle, October 19, 1894, No. 1487; Rochester, September 27, 1917, No. 4653. A long-spiked form may be known as *Spartina Michauxiana* Hitchc. var. SUTTIEI n. var. An extreme form with panicle over a foot and a half in length, with fewer, longer spikes 5-7 inches long on peduncles 1½-2 inches. Island Lake, July 16, 1905, No. 1487a. Also Dr. George Suttie, Orchard Lake, July 29, 1892, and Waterford, August 27, 1893. A slender form may be known as *Spartina Michauxiana* Hitchc. var. TENUIOR n. var. More slender than the species, 3-4 feet high, panicle 1-1½ feet or more long, spikes 1-3 inches in length, scattered, alternate, only slightly exceeding the internode, the uppermost usually shorter than the internode, the terminal often elongated (4-5 inches), sessile or on short (not exceeding ⅜ of an inch) peduncles; 1st glume, with an awn equal to its own length or shorter, ⅛-⅜ the length of the floret; palet about ½ line longer than its lemma and about equal to the second glume, which has an awn equal to its own length or shorter. Spikelet, exclusive of awn, about four lines long. In dry sandy fields at River Rouge, September 15, 1918, No. 5138. Apparently a transition towards *S. alterniflora*, which it strongly resembles, but the first and second glumes are prominently awned,

[1]A larger form of the species with glabrous stems and leaves, but with the lowest sheaths rough, with short reflexed pubescens, is the var MAJUS (Vasey) n. comb. (*Trisetum majus* (Vasey) Rydb.) Sunset Peak, Colorado, August 30, 1911, No. 2455½.

and the keel of the lemma ends abruptly at the sinus of the two-toothed apex, which characters will place it here. The keels and awns are sparsely hispid, otherwise the floret is glabrous.

Atheropogon Muhl. is scarcely distinct generically from Bouteloua Lag. The species is *Bouteloua curtipendula* (Mx.) Torr. Dry hillsides near Rochester, July 30, 1914, No. 3807.

Phragmites Trin. is equivalent to Arundo L. The generic description of Linnaeus in the 5th ed. of the Genera, page 35, 1754, is of this genus. The species is *Arundo Phragmites*, L. Keweenaw county, August 8, 1888, No. 641. Parkedale, August 4, 1912, No. 3013. St. Clair Flats, September 27, 1909, No. 641a. Trichoon Roth, 1798, is also a synonym and has 14 years priority over Phragmites Trin. 1812, and is the proper name to be taken up for the genus by those who think Arundo L. equivalent to Donax Beauv. The name would be *Trichoon Phragmites* (L.) Schinz & Thell.

Tricuspis seslerionides becomes *T. flava* (L.) Hubbard.

Briza media L. Grosse Pointe, July 21, 1906, No. 1986.

Briza minor L. Grosse Pointe, July 21, 1906, No. 1987.

Poa flava (L.) of the Michigan Flora is now known as *P. palustris* L.

Panicularia Americana becomes *P. grandis* (S. Wats.) Nash.

P. fluitans (L.) O. K. is an European species, the typical form of which is found in only a few places in North America. Banks of Detroit River, October 2, 1900, No. 1697.

P. FLUITANS var. SEPTENTRIONALIS (Hichk.) n. comb. (*P. septentrionalis* Hitchk. Rhodora VIII, 211, 1906). Has shorter florets and spikelets than the species. Detroit, July 7, 1907, No. 2033; Rochester, August 15, 1909, No. 2033a; Parkedale, August 4, 1912, No. 3044; Port Huron, June 23, No. 4961.

P. FLUITANS var. SEPTENTRIONALIS f. GLAUCA, *n. f.* Whole plant densely glaucous, Rockwood, June 16, 1918, No. 4893.

P. fluitans var. *angustata Vasey.* (*P. borealis* Nash.) Spikelets and florets still shorter, especially the former. Detroit, June 17, 1911, No. 2215½; Parkedale, July 19, 1914, No. 3727, and July 4, 1918, No. 3030; Bloomfield, June 29, 1918, No. 4999, (Farwell & Billington). These various forms show a perfect graduation from one extreme to the other and should therefore be treated as one species, rather than as two or more distinct species.

Puccinellia Parl. becomes Atropis Trin. The latter name has three years priority over Puccinellia, and is the name in general use by European botanists for this group of species. Our species becomes *A. airoides* (Nutt.) Holm.

Festuca ovina L. var. *duriuscula* (L.) Koch. f. *villosa* (Schrad.) As. & Gr. A form in which the lemmas are pubescent. Rochester, July 4, 1901, No. 1722; Algonac, May 24, 1914, No. 3641.

F. rubra heterophylla Hack. is now generally known as *F. occidentalis* Hook.

Bromus aspera Murr. Stevens, July 14, 1918, No. 5087.

Bromus brizaeformis Fisch. & Mey. Detroit, June 30, 1907, No. 2027.

Bromus hordeaceus var. *leptostachys* (Pers.) Beck. Parkedale, August 4, 1912, No. 3033a.

Bromus Japonicus Thunb, Ypsilanti, June 25, 1910, No. 2158½.

Bromus purgans L. This species is now generally considered to be distinct from *B. ciliatus* L. Keweenaw county, August 26, 1887, No. 563; Rochester, July 4, 1896, No. 563a; Detroit, August 18, 1907, No. 563b; Parkedale, July 14, 1912, No. 2856.

Bromus purgans var. *latiglumis* Shear (*B. altissimus* Pursh). Detroit, June 30, 1907, No. 2026; Franklin, September 23, 1918, No. 5161.

Bromus purgans var. *incanus* Shear (*B. incanus* (Shear) A. S. H.) Detroit, June 30, 1907, No. 2029; Rochester, October 10, 1918, No. 5194.

Bromus racemosus var. *commutatus* (Schrad.) Hook. f. (*B. commutatus* Schrad.) Ypsilanti, June 21, 1892, No. 1246; Belle Isle, July 21, 1892, No. 1246a; Parkedale, July 14, 1912, No. 2841½.

Bromus squarrosus L. var. *villosus* (Gmel.) Koch. Belle Isle, September 20, 1896, No. 1558.

Lolium L. In addition to the species listed in the Michigan Flora we have the following:

Lolium perenne var. *tenue* L. Detroit, July 22, 1911, No. 2219.

Lolium multiflorum Lam. Detroit, August 8, 1970, No. 2181.

Lolium festucaceum Link. Detroit, June 15, 1910, No. 2157.

The genus Agropyron is widely distributed in Michigan and is represented by many species and varieties. The revised list follows:

A. caninum (L.) R. & S. (*A. caninoides* (Ramalay) Beal.) Keweenaw county, June 27, 1895, No. 533b; Marquette, July 6, 1895, No. 533e; Detroit, September 8, 1897, No. 533f; Island Lake, July 16, 1905, No. 533g; Parkedale, July 4, 1918, No. 5029. A plant with long, slender, cylindrical spikes, spikelets appressed and florets long awned.

A. caninum var. *pubescens* Scrib & Sm. Keweenaw county, August 15, 1887, No. 533, and June 27, 1895, No. 533d; Rochester, July 24, 1910, No. 533h.

A. caninum var. *unilaterale* (Cassidy) Vasey. (*A. Richardsoni* (Trin.) Schrad.) A form with larger spikes, awns purplish and spiklets secund, or one-sided on the spike. Keweenaw county, June 27, 1895, No. 533a.

Agropyron divergens Nees (*Agropyron spicatum* (Pursh) Rydb. Fl. Mont. 61, 1900, not Scribn. & Sm. 1897). Keweenaw county, July 4, 1895, No. 851b.

Agropyron divergens var. *inerme* Scribn. & Sm. Keweenaw county, July 4, 1895, No. 851c.

A. biflorum (Brign.) *R. & S.*, (*A. violaceum* (Hornem.) Lange). Keweenaw county, June 27, 1895, No. 533c.

A. tenerum Vasey. Keweenaw county, August 15, 1887, No. 532a and July 8, 1890, No. 760.

A. TENERUM var. NOVAE-ANGLIAE (Scribn. & Sm.) n. comb. (*A. repens* var. *Novae-Angliae* Scribn. & Sm. U. S. Bull. Agrost IV,—,1897; *A. pseudorepens Scribn. & Sm.* l. c., 34; *A. Novae-Angliae Scribn.* in Fl. Vt.,—. 1900). Keweenaw county, July 3, 1895, No. 851a; Marquette, July 6, 1895, No. 851d.

Agropyron repens (Lin.) Beauv. This species is common throughout Michigan in many forms. Keweenaw county, August 15, 1887, No. 532; Ypsilanti, June 21, 1892, No. 532b; Belle Isle, July 23, 1892, No. 532c; Marquette, July 6, 1895, No. 532d; Parkedale, July 28, 1912, No. 2923, August 4, 1912, No. 2964.

Agropyron repens f. *geniculatum*, Farwell. Detroit, June 24, 1899, No. 1634.

Agropyron repens f. *stoloniferum*, Farwell. Detroit, June 24, 1899, No. 1635.

Agropyron repens var. *agreste*, Anders. Detroit, June 24, 1899, No. 1632.

Agropyron repens var. *nemorale*, Anders. Keweenaw county, July 18, 1890, No. 759; Detroit, June 24, 1899, No. 759a; Lake Linden, August 24, 1912, No. 3078; Rochester, June 23, 1912, No. 2927, and June 15, 1913, No. 3492½; Orion, July 7, 1918, No. 5049.

Agropyron repens var. *pilosum* Scribn. Detroit, June 24, 1899, No. 1633; Belle Isle, July 20, 1899, No. 1633a; Parkedale, July 28, 1912, No. 2950, and July 4, 1918, No. 5024.

Agropyron repens var. *littoreum* Anders. Keweenaw county, September 10, 1887, No. 595.

Agropyron dasystachyum (Hook.) Vasey. Keweenaw Penninsula, August 18, 1890, No. 794.

Agropyron dasystachyum var. *subvillosum* Scribn. & Sm. Keweenaw county, June 27, 1895, No. 794a.

Agropyron spicatum Scribn. & Sm. (*A. Smithii* Rydb. Fl. Mont., 64, 1900; *A. occidentale* Scribn. U. S. Agrost. Circ. XXVII 9, 1900; *A. repens* var. *glaucum* Scribn. Mem. Tor. Club. V. 57, 1895). The fact that Scribner & Smith misidentified the *Festuca spicata* of Pursh does not invalidate the above binomial for the species they described, since the binomial always applies to the species described. Had those authors based their new combination solely on synonymy (without a description) the name would, perforce, have been a synonym of Pursh's species, the one on which it would have been based. As I understand this species, it is characterized by its glaucous, bluish-green appearance, which makes it stand out boldly and conspicuously from all surrounding herbage. Rochester, June 23, 1912, No. 2828; Detroit, June 17, 1911, No. 2214b.

AGROPYRON SPICATUM var. VIRIDE, n. var. Larger and coarser than the species with a longer spike and larger spikelets, whole plant pale green, not at all bluish nor glaucous. Detroit, Mich., June 24, 1899, No. 851e; Keweenaw county, July 3, 1895, No. 851.

Triticum aestivum L., the Bearded Wheat, is adventive in southern Michigan. Detroit, June 17, 1895, No. 842a; Keweenaw Co., Aug. 1894, No. 842.

TRITICUM AESTIVUM var. MUTICUM (Alef.) n. comb. (*Triticum vulgare* var. *muticum* Alef. Landw. Fl. 328, 1866). The Beardless Wheat is adventive in southern Michigan. Detroit, June 13, 1895, No. 841a; Keweenaw county, August, 1894, No. 841.

TRITICUM AESTIVUM var. LEUCOSPERMUM (Körn.) n. comb. (*T. vulgare.* var. *leucospermum* Körn. *System.*. Ubers. 10, 1873). Spikes densely velvety; the lemmas are awnless or short awned and velvety pubescent. Roadsides, near Rochester, June 30, 1912, No. 2799.

Hordeum vulgare L. Keweenaw county, August, 1894, No. 843; Detroit, July 8, 1905, No. 843a; Houghton, August 28, 1912, No. 3098; Parkedale, August 13, 1909, No. 843b.

Hordeum vulgare var. *distichon* (L.) Alef. Parkedale, August 13, 1909, No. 2100a.

Hordeum vulgare var. *hexastichon* (L.) Alef. Parkedale, August 13, 1909, No. 2100b.

Secale Cereale, L. Sandy hillsides at Houghton, August 28, 1912. No. 3099.

Secale Cereale var. *vulgare* Körn. Belle Isle, June 20, 1893. No. 1373.

Secale Cereale var. *multicaule*, Körn. Rochester, June 8, 1909, No. 1373a.

Elymus Canadensis, L. (*E. Canadensis* var. *glaucifolius* (Willd.) Torr.) Rather scarce. This glaucous plant is the Linnaean species. Detroit, September 17, 1896, No. 1556; Rochester, September 6, 1909, No. 1556a.

Elymus Canadenseis L. var. PHILADELPHICUS (L.?) n. var. (*E. Philadelphicus* L. Cent. 1, No. 14, 1755? *E. Canadensis* Amer. authors not Lin.) The green, non-glaucous plant. Marquette, August 30, 1898, No. 1619½; Rochester, September 6, 1909, No. 1619b; Monroe Piers, August 10, 1909, No. 2184½.

ELYMUS CANADENSIS var. BRACHYSTACHYS (Scrib. & Ball.) n. comb. (*E. brachystachys* Scribn. & Ball. U. S. Agrost. Bull, XXIV, 47, fig. 21, 1901). Very common throughout southern Michigan. Belle Isle, August 11, 1893, No. 1409; Orion, August 29, 1895, No. 1409a; Island Lake, July 16, 1905, No. 1929½; Rochester, August 15, 1909, No. 2109½.

ELYMUS CANADENSIS var. ROBUSTUS (Scribn. & Sm.) n. comb. (*E. robustus* Scribn. & Sm. U. S. Agrost. Bull, IV, 37, 1897). Has been reported from various places. The type of the species according to the Linnaean description and explanatory remarks can be no other than Wildenow's *E. glaucifolius*. The non-glaucous plant that has been passing as *E. Canadensis* L., may be *E. Philadelphicus* L. (?) and may be considered as a good variety of the former. *E. robustus* differs from the var. *Philadelphicus* only in a denser spike, less alternate at base, which is scarcely a specific character. *E. brachystachys* differs in having the glumes and lemmas hispidulous or glabrate, characters that are only of varietal rank.

Elymus striatus Willd. var. *villosus* (Muhl.) A. Gr. This variety should be maintained as valid for the same reason that var. *brachystachys* is maintained. In the species the spikelets are hispid and in the variety they are hirsute. On this slender character *E. brachystachys* (Scribn. & Ball) is maintained as a valid species by some, but in the case of *E. villosus Muhl*, an exactly parallel case, the name is reduced to the limbo of synonymy. The species is reported as occurring throughout Michigan. The only form I have seen is the variety. Belle Isle, October 19, 1894, No. 1490.

Asperella Humb. has three years priority over Hystrix Moench.; the species is *Asperella Hystrix* (L.) Humb. Ypsilanti, July 23, 1891, No. 1174; Belle Isle, July 21, 1892, No. 1174a.

CYPERACEAE.

Cyperus inflexus Muhl. should be *C. aristatus* Rottb.

Cyperus esculentus var. *leptostachyus* Boeckl. is characterized by its much elongated spikelets (¾-1½ in.) Near Birmingham, October 13, 1918, No. 5214.

Cyperus filiculmus Vahl is common on dry sterile grounds. Parkedale, August 23, 1914, No. 3845. The var. *macilentus* Fernald is found in same

situations, but is much less common. Near Ypsilanti, July 31, 1891, No. 1189; Detroit, July 19, 1894, No. 1189a; Rochester, July 4, 1896, No. 1189b, and September 28, 1911, No. 2956; Marl Lake, August 15, 1917, No. 4546.

Trichophyllum Ehrh. has 21 years priority over Eleocharis R. Br. Presumably the reason Ehrhart's name has been neglected may be found in the generally conceded preponderating weight of the influence inseparable from the authority that goes with the name of Robert Brown, aided, no doubt, by the ex-post facto laws passed by botanical congresses, the members of which have had no inclination to learn the many new names for old species that it would be necessary to adopt in case the changes were made, always a sign of retrogression, rather than of progression. The names of Michigan species not already transferred follow:

T. INTERSTINCTUM (Vahl.) n. comb. (*Scirpus interstinctus* Vahl. Enum. II 251, 1806).

T. MUTATUM (L.) n. comb. (*Scirpus mutatus* L. Amoen. Acad. V. 391, 1760).

T. ROBBINSII (Oakes) n. comb. (*Eleocharis Robbinsii* Oakes, Hovey's Mag. VII, 178, 1841).

T. OLIVACEUM (Torr.) n. comb. (*Eleocharis olivacea* Torr. Ann. Lyc. N. Y. III 300, 1836).

T. OVATUM (Roth) n. comb. (*Scirpus ovatus* Roth. Catal. Bot. I 5, 1797). On the Keweenaw Peninsula, but scarce. August 22, 1887, No. 547.

T. OBTUSUM (Willd.) n. comb. (*Scirpus obtusus* Willd. Enum. 76, 1809). Very common throughout. Keweenaw county, August 22, 1887, No. 547a; Belle Isle, August 6, 1882, No. 547b; Royal Oak (Zoo Park), July 13, 1916, No. 4320.

T. PALUSTRE var. GLAUCESCENS (Willd.) n. comb. (*Scirpus glaucescens* Willd. Enum. 76, 1809). Keweenaw county, July 25, 1890, No. 772; Ypsilanti, June 21, 1892, No. 772a; Detroit, July 10, 1892, No. 772b, and July 7, 1893, No. 772c; Tacoma, July 2, 1916, No. 4270. A slender, filiform condition of the species.

T. PALUSTRE var. CALVUM (Torr.) n. comb. (*Eleocharis calva* Torr. Fl. N. Y. II, 346, 1843). A low slender form without bristles. Grosse Pointe and Belle Isle, July 21, 1906, No. 1988.

T. PALUSTRE var. VIGENS (Bailey) n. comb. (*Eleocharis palustris* var. *vigens* Bailey, Journ. N. Y. Micros. Soc. V 104, 1889). A very stout and rigid form of the species. Keweenaw county, July 25, 1890, No. 773.

T. ENGELMANNI (Stued.) n. comb. (*Eleocharis Engelmanni* Stued. Syn. Pl. Cyp. 79, 1855). Detroit, October 2, 1900, No. 1696.

T. ACICULARE (L.) n. comb. (*Scirpus acicularis* L. Sp. Pl. 48, 1753). Keweenaw county, September 6, 1888, No. 676; Belle Isle, August 6, 1892, No. 676a; Orion, August 29, 1895, No. 676b; Ypsilanti, July 31, 1891, No. 676c; Lake Linden, August 24, 1812, No. 3081; Tacoma, July 2, 1916, No. 4268.

T. TENUIS (Willd.) n. comb. (*Scirpus tenuis* Willd. Enum. 76, 1809). Keweenaw county, August 18, 1890, No. 548a.

T. ACUMINATUM (Muhl.) n. comb. (*Scirpus acuminatus* Muhl. Gram. 27, 1817). Keweenaw county, August 22, 1887, No. 548.

T. INTERMEDIUM (Muhl.) n. comb. (*Scirpus intermedius* Muhl. Gram. 31, 1817).

IRIA CASTANEA (Mx.) n. comb. (*Scirpus castaneus* Mx. Fl. Bor. Amer. I, 31, 1803).

IRIA AUTUMNALIS (L.) O. K. var. GEMINATA (Lestib. & Nees) n. comb. (*Trichelostylis geminata* Lestib. & Nees, Fl. Bras. II pt. 1, pp. 79 and 80, 1842). Iria Richard has a year's priority over Fimbristylis Vahl; Otto Kunze took up the name, but changed the spelling to Iriha. The old *F. autumnalis* (L.) R. and S., has been split and that part of the species retaining the old name is of southern range. That part of the species extending further north has been known as *F. geminata* (Lestib. & Nees) Kunth or *F. Frankii* Steud. The characters used to distinguish the two forms are so slight that it seems better to retain them as variations of the same species. The Michigan plant, presumably, is of the variety geminata, as its range is too far north for it to be likely that it should belong to the typical form of the species. I haven't seen it.

Scirpus lacustris L. has been restricted to the Old World. The American plant is mostly the *S. validus* Vahl. Keweenaw county, September 6, 1888, No. 677; Ypsilanti, June 23, 1891, No. 677a; Detroit, August 6, 1892, No. 677b, and July 18, 1912, No. 2874; Parkedale, August 4, 1912, No. 2994; Grosse Isle, August 20, 1916, No. 4387; Tacoma, September 23, 1917, No. 4624.

S. occidentalis (Watson) Chase. Keweenaw county, August, 1904, No. 1834; Parkedale, July 28, 1912, No. 2918; Marl Lake, August 13, 1916, No. 4377.

S. occidentalis var. *congestus*, O. A. F. Marl Lake, July 9, 1916, No. 4294, and August 13, 1916, No. 4376.

S. heterochaetus Chase. Another segregate of the old *S. lacustris* L., which is said to occur in Michigan.

S. atrovirens Muhl var. *pycnocephalus* Fernald. Parkedale, August 4, 1912, No. 3021. The infloresence in this has been reduced to a glomerate head.

S. rubrotinctus Fernald. This is the old *S. microcarpus* Presl. Keweenaw county, September 12, 1887, No. 549a.

S. sylvaticus L. Keweenaw county, August, 1904, No. 1824; Junior, July 13, 1918, No. 5079.

S. Georgianus Harper. Accredited to Michigan in Gray's Manual.

S. Cyperinus (L.) Kunth. *S. lineatus* Mx. and allied species should be removed to Eriophorum. The elongated bristles exclude them from Scirpus, but if they are to be retained in that genus, then all distinctions between it and Eriophorum break down and both should be united. It would be better to restore the old genus Trichophorum for this group of plants than to retain them in Scirpus.

E. lineatum (Mx.) Bth. & Hk. f. Keweenaw county, August 21, 1890, No. 799; Ypsilanti, June 23, 1891, No. 799a; Detroit, July 21, 1892, No. 799b.

E. Cyperinum L. Keweenaw county, September 6, 1888, No. 678; Detroit, September 15, 1899, No. 678a.

E. Cyperinum var. pelium (Fernald) O. A. F. Keweenaw county, August 8, 1890, No. 756b, and August 15, 1901, No. 1736; Detroit, August 4, 1896, No. 756c; Marl Lake, August 13, 1916, No. 4358.

E. CYPERIUM var. PELIUM f. CONDENSATUM (Fern.) n. comb. (*Scirpus cyperinus* var. *condensatus* Fernald; Gray Manual, 195, 1908). Accredited in the Manual to Michigan.

E. Cyperinum var. *laxum* Wats. & Coult. (*Scirpus Eriophorum* Mx. Fl. Bor. Am. I, 33, 1803). Detroit, September 18, 1902, No. 1795.

E. Cyperinum var. pedicellatum (Fernald) O. A. F. (*E. cyperinum* var. *laxum* Wats & Coult. in part). Keweenaw county, August, 1904, No. 1826½.

E. CYPERINUM var. PEDICELLATUM f. GRANDE n. comb. (*Scirpus atrocinctus* var. *grandis* Fernald, and *S. pedicellatus* var. *pullus* Fernald. Gray Manual 195, 1908). Keweenaw county, August, 1902, No. 1788.

E. Cyperinum var. *atrocintum* (Fernald) O. A. F. (*E. Cyperinum* var. *laxum* Wats. & Coult. in part). Keweenaw county, July 18, 1890, No. 756.

E. CYPERIUM var. ATROCINATUM f. BRACHYPODUM (Fernald) n. comb. (*S. atrocinctus* var. *brachypodus* Fernald, Proc. Am. Acad. XXIV, 502, 1899). Keweenaw county, August 18, 1890, No. 756a.

Typical *E. vaginatum* L. is now restricted to the Arctic regions. The Michigan material is referred to two varieties. *E. vaginatum* var. *humile*, Turcz. (*E. callitrix* Cham.) Keweenaw county, August 22, 1887, No. 55, and *E. vaginatum* var. *opacum* Bjornstr. Lakeville, Farwell and Billington, June 2, 1918, No. 4907.

E. gracile Koch. Keweenaw county, August 22, 1887, No. 551.

E. gracile var. *paucinervium* Engelm. Keweenaw county, August, 1901, No. 1735. Neither form of the species is common. The variety has the blade of the uppermost leaf longer than its sheath, while in the species it is shorter.

E. polystachion L. (*E. angustifolium* Roth.) Keweenaw county, September 10, 1888, No. 691.

E. polystachion var. *majus* (Schultz) As. & Greb. This variety is accredited to Michigan in Gray's Manual.

E. POLYSTACHION var. VIRIDI-CARINATUM (Engelm) n. comb. (*E. latifolium* var. *viridi-carinatum* Engelm. Am. Jour. Sci. XLVI, 103, 1844). Keweenaw county, July 12, 1890, No. 743; Parkedale, June 2, 1912, No. 2614.

Phaeocephalum Ehrh. (Triodon Pers. and Rynchospora Vahl) appears to be the oldest name for the genus. The Michigan species are the following:

P. ALBUM (L.) n. comb. (*Schoenus albus* L. Sp. Pl. 44, 1753). Keweenaw county, August 22, 1887, No. 552; Rochester, August, 1908, No. 552a; Marl Lake, August 13, 1916, No. 4374.

P. ALBUM var. MACRUM (Clarke) n. comb. (*Rynchospora alba* var. *macra* Clarke in Britt. Trans. N. Y. Acad. Sci. XI, 88, 1892).

P. CAPILLACEUM (Torr.) n. comb. (*R. capillacea* Torry Comp. 41, 1826). Orion, Aug. 29, 1895, No. 884; Marl Lake, Aug. 13, 1916, No. 4366; Parkedale, July 14, 1912, No. 2858.

P. CAPILLACEUM var. *levisetum* (E. J. Hill) n. comb. (*R. capillacea* var. *leviseta* E. J. Hill; Gray's Manual 201, 1908). Orion, Aug. 29, 1895, No. 911.

P. GLOMERATUM (L.) (*Schoenus glomeratus* L. Sp. Pl. 44, 1753) var. MINUS (Britt.) n. comb. (*R. glomerata* var. *minor* Britt. Trans. N. Y. Acad. Sci. XI 89, 1892). The variety only is found in Michigan. Ypsilanti, Aug. 12, 1891, No. 1199; Detroit, July 27, 1893, No. 1199a; Keweenaw Co., Aug. 1904, No. 1199b; Parkedale, July 28, 1912, No. 2919.

P. CYMOSUM (Ell.) n. comb. (*R. cymosa* Ell. Sketch. I 58, 1816.)

P. FUSCUM (L.) n. comb (*Schoenus fuscus* L. Sp. Pl. 1664, 1763).

Carex sterilis Willd. (*C. scirpoides* Schk.) There are two forms of this species found here in Michigan. One is found in open bogs and swamps and along the borders of woods and the other in dense boggy woods such as tamarack swamp, cedar swamps, etc., where sphagnum is liable to be found. The former has the stiff, wiry habit of *C. echinata*, but the leaves are narrower, 1 to 1¼ lines wide and the perigynia are broader, the width being more than ½ the length, and gradually tapering into the inconspicuously bifid beak, the edges being strongly roughened, about 1¼ lines long by about ⅞ line wide, finally becoming yellowish or brownish. Often dioecious. This form probaby is typical of Willdenow's *C. sterilis*. The latter is slender, lax, with leaves only ½ as wide, the green perigynia abruptly contracted into the beak, the edges being minutely roughened; it is essentially the plant described by Bailey as *C. interior*. It seems to the present writer that the difference outlined is mainly that which might be sought in a shade form of an ordinarily sunlight plant and therefore this form should be properly treated as a variation rather than as a distinct species. It may be known as *C. sterilis* Willd. f. FLEXIBILIS, n. f. Lakeville, June 2, 1918, No. 4887.

Carex vulpinoidea Mx. var. *ambigua* Barratt. A rare form of the species in Michigan. Spikes yellowish brown and forming a strong contrast to the usually green or brownish spikes of the species. Detroit, June 16, 1900, No. 1670; Junior, July 13, 1918, Farwell & Billington, No. 5074.

Carex stricta Lam. var. *strictior* (Dew.) A. Gr. (*C. stricta* var. *curtissima* Peck). Does not form dense tussocks as does the species. Keweenaw Point, Aug. 26, 1887, No. 565, and Aug. 1904, No. 1831½; Ypsilanti, July 29, 1906, No. 565b; Orion, June 9, 1918, No. 4,933.

Carex stricta Lam. var. *xerocarpa* (S. H. Wright) Britton. In moist woods near Rochester, May 28, 1918, No. 4875 and No. 4882c.

Carex aurea Nutt f. COLORATA n. f. The scales pale brown. In tamarack swamps at Lakeville, June 2, 1918, No. 4882g.

Carex Harperi Fernald (?). These plants appear to be intermediate between this species and *C. leptalea* Wahlenb. The persistent scales are brownish and mucronate instead of white and acuminate, but the perigynia are slender, and gradually tapering at the base and the achenes are puncticulate and sharply trigonous as in *C. Harperi.*. Orion, June 9, 1918, No. 4929; Parkedale, July 4, 1918, No. 5034.

Carex umbellata Schkuhr. var. *brevirostris* Boot. Banks of the Huron River at Ypsilanti, May 19, 1918, No. 4831, Billington & Farwell.

Carex Pennsylvanica Lam. var. *lucorum* (Willd.) Fernald. Port Huron, June 23, 1918, No. 4985; Detroit, June 11, 1903, No. 1800.

Carex paupercula Mx. var. *irrigua* (Wahl.) Fernald. In bogs. Keweenaw Point, Sept. 12, 1887, No. 608, and Aug. 26, 1912, No. 3090; Orion, July 7, 1918, No. 5055, Farwell & Billington.

Carex paupercula Mx. var. *pallens* Fernald. Keweenaw Co., July 5, 1895, No. 854½; Orion, July 7, 1918, No. 5040a, Farwell & Billington.

Carex laxiflora Lam. var. *leptonervia*, Fernald. This is accredited to Michigan in Gray's Manual. Port Huron, June 23, 1918, No. 4977, Farwell & Billington. Rare. In rich woods.

Carex flava L. var. *rectirostra* Gaudin (*C. flava* var. *graminis* Bailey). Borders of Marl Lake, rare, June 9, 1918, No. 4923; Keweenaw Co., Aug. 24, 1888, No. 672; Dead Lake, July 16, 1910, No. 672b.

Carex lanuginosa Mx. var. *Kansana*, Britt. Plant with leaves ½ narrower than in the species, spikes longer, narrower, and tapering at base. Roadsides near Rochester, May 28, 1918, No. 4882f.

Carex retrorsa Schwein var. *Robinsonii* Fernald. A form with slender spikes. Rare. Ypsilanti, July 23, 1891; Dearborn, July 6, 1918, No. 5029.

Carex lupulina Muhl var. *polystachya* Schw. & Torr. Common at Junior in low moist grounds. July 13, 1918, No. 5064, Billington & Farwell.

Carex vesicaria L. Roadside ditches near Lakeville. The typical species not before reported from Michigan in so far as I am aware. June 2, 1918, No. 4883, Farwell & Billington.

LILIACEAE.

Erythronium Americanum Ker. var. Bachii, n. var. A form in which the lower half of the perianth segments, and stamens are purplish brown or magenta. Near Redford, May 19, 1918, No. 4851. Named for Mr. Bach of Detroit, who found it in considerable numbers.

Trillium recurvatum Beck. Perhaps the rarest Trillium in Michigan. Near Rochester, May 15, 1918, No. 4822. Has been reported from Ypsilanti.

Trillium cernuum var. declinatum (A. Gr.) n. comb. (*T. erectum* L. var. *declinatum* A. Gr. Manual, 523, 1868). This plant certainly is closely related to *T. cernuum* L. In the "copper region" of Michigan where both are plentiful they seem to intergrade and at times it is very difficult to determine to which form certain individuals should be referred. It seems better to regard them as extremes of one species rather than as two. Keweenaw Co., July 8, 1886, No. 411; Ypsilanti, May 19, 1918, No. 4848.

T. cernuum L. var. *declinatum* A. Gr. f. Walpolei n. f. Petals and often the filaments and stigmas deep purple. Named for Mr. B. A. Walpole of Ypsilanti, one of the discoverers. Ypsilanti, May 19, 1918, No. 4849.

T. cernuum L. var. *declinatum* A. Gr. f. BILLINGTONII n. f. Flowers brown with a slight tinge, here and there, of a purplish color. Named for one of the discoverers, Mr. Cecil Billington, of Detroit. Ypsilanti, May 19, 1918, No. 4850.

Trillium grandiflorum (Mx.) Salisb. f. ROSEUM n. f. Flowers rose-colored. Ypsilanti, May 19, 1918, No. 4847; Birmingham, May 18, 1902, No. 767c. *T grandiflorum* is common throughout eastern North America. I have seen acres of it and probably many thousands of individuals without a rose-colored flower to change the monotony of the pure white of the open woods as far as the eye could detect them. In some localities rose-colored flowers are more common than the normal white flowered form but such places are few in comparison. In these localities, the rose-colored individuals appear as though they had been rose-colored from the beginning and do not lose the color even in the withered and shrunken petals. The nearby white flowered forms when faded and wrinkled up are not rose-colored but present the dirty-white or dull yellowish-white color characteristic of such conditions. It seems probable that the "rose" and the "white" in this species are as permanent as the "purple" and "white" in *T. erectum* L. or in *T. cernuum* L.

T. grandiflorum var. *obovatum* f. ALBIFLORUM n. f. (*T. grandiflorum* var. *obovatum* O. A. F. Mich. Acad. Sci. Rept. 1918, p. 157; *T. grandiflorum* var. *parvum* Gates Ann. Mo. Bo. Gard. IV. 58, 1917, as of the white flowered forms). Flowers white. Farmington, May 19, 1917, No. 1443. The remarks above concerning the color forms of the species apply equally well to the color forms of this variety. I may add that of the myriads of individuals observed I have never seen the rose color beginning to develop in a white petal after it had begun to fade. On the other hand, I have never examined a bud to ascertain if the petals at that stage of development were of a rose color.

CASTANEACEAE.

Quercus stellata Wang. The Post Oak reported in the 20th Annual Report, Mich. Acad. Sci. p. 172, as *Quercus lyrata* Walt, should have been listed as *Quercus stellata* Wang.

ARISTOLOCHIACEAE.

The flowers of the genus Asarum are said to be 3-merous. Mr. Walpole, of Ypsilanti, has found *A. Canadense* L. near that city to be 4-merous almost as frequently as it is 3-merous.

PERSICARIACEAE.

Polygonum amphibium L. (*P. amphibium* var. *aquaticum* Leyss. Fl. Hal. 391, 1761; *P. amphibium* var. *palustre* Weig. Fl. Pom. 255, 1769, according to Ascherson and Graebner; *P. amphibium* var. *natans* Moench. Enum. Pl. Hass. 28, 1777). A glabrous aquatic with narrowly oblong-lanceolate acute floating

leaves, usually narrowed but occasionally rounded at base. Keweenaw Co., Sept. 4, 1885, No. 352.

P. amphibium f. *terrestra* (Leyss.) S. F. Blake. (*P. amphibium* var. *terrestre* Leyss. Fl. Hal. 391, 1761; *P. amphibium* var. *erectum* Kittel, Tauschenb. 303, 1853; *P. amphibium* var. *salicifolium* Schur, Enum. Pl. Transs. 583, 1866). A terrestrial, decumbent to erect, strigose pubescent variation. Algonac, Sept. 13, 1915, No. 3895; Detroit, Sept. 20, 1918, No. 5151.

P. amphibium var. *marginatum* n. var. Differs from the typical form of the species only in having a foliaceous border on the stipular sheaths. Keweenaw Co., Sept. 4, 1885, No. 351.

P. AMPHIBIUM var. MARGINATUM f. HARTWRIGHTII n. comb. (*P. amphibium* var. *Hartwrightii* (A. Gr.) Bissell, Rhodora IV 105, 1902). A terrestrial, decumbent to erect, strigose pubescent variation. Belle Isle, Aug. 2, 1892, No. 351a; Lakeville, Sept. 2, 1901, No. 351b; Parkedale, July 30, 1914, No. 3812; Bloomfield, June 29, 1918, No. 5002.

P. amphibium var. *natans* Mx. (*P. coccineum* Muhl. and var. *aquaticum* Willd. *P. amphibium* var. *coccineum* (Muhl.) O. A. F. Aquatic; leaves ovate-lanceolate, usually cordate; plant glabrous. Belle Isle, Sept. 3, 1892, No. 352a.

P. amphibium var. *natans* f. EMERSUM (Mx.) n. f. (*P. amphibium* var. *emersum* Mx. Fl. Bor. Amer. I, 240, 1803; *P. coccineum* var. *terrestre* Willd. Enum. I, 429, 1809; *P. amphibium* var. *terrestre* Torr. F.l N. Y. II, 149, 1843; *P. amphibium* var. *Muhlenbergii* Meisn. in DC. Prodr. XIV, 116, 1856). An erect, terrestrial, strigose pubescent form. Belle Isle, Oct. 19, 1893, No. 1452; Grosse Isle, Aug. 14, 1909, No. 1452a. It has been said that the terrestrial forms are but mere phases and may be found on the same rhizomes which produce the aquatic plants. My experience shows that the terrestrial forms are rather common in Michigan, while the aquatics are infrequent. I have never seen the two phases associated or even in close proximity to each other.

Polygonum aviculare L. var. *vegetum* Ledeb. Along roadsides in the Bloomfield hills. Prostrate. Billington & Farwell, June 29, 1918, No. 4989. Also in Detroit, where the plants were ascending or erect.

BLITACEAE.

Chenopodium album L. A common and variable weed throughout the State. Ypsilanti, June 17, 1891, No. 1152; Detroit, July 16, 1892, No. 1152a; Keweenaw Co., June 26, 1895, No. 1152b. The following varieties are also distinguishable.

C. album var. *opulifolium* (Schrad.) G. Meyer. (*C. viride* L.) Leaves thinner, less toothed and acute or entire and obtuse, greener, the lower as broad as long. Keweenaw Co., Aug. 12, 1885, No. 311; Ypsilanti, Sept. 2, 1891. No. 311c; Belle Isle, July 21, 1892, No. 311d.

C. album var. *integerrimum* S. F. Gray, (*C. lanceolatum* Muhl.) Leaves usually narrowly lanceolate and entire. Detroit, Sept. 9, 1895, No. 311b.

C. album var. *viridescens* St. Am. (*C. paganum* Reichenb). Leaves green and panicle lax. Oakwood, Sept. 15, 1918, No. 5135.

Salsola Kali L. var. *Caroliniana* (Walt.) Nutt. Leaves short, plant glabrous. Rochester. Oct. 6, 1918, No. 5187.

S. Kali var. *tenuifolia* Tausch. Leaves long and filiform, plant usually rough. Rochester. Oct. 6, 1918, No. 5188.

RANUNCULACEAE.

Anemone cylindrica A. Gr. f. ALBIDA n. f. Sepals petal-like white, thin, obovate, oval, or ovate, 4-8 lines in length. Parkedale, July 4, 1918, No. 5016.

POMACEAE.

Crataegus pruinosa (Wendl.) C. Koch. Near Redford, May 24, 1918, No. 4863.

C. Jesupi Sarg. Franklin, Sept. 22, 1918, No. 5162.

ROSACEAE.

Rosa Carolina L. (*R. humilis* Marsh.) One of our common wild roses and immensely variable. The leaflets vary from obovate or oblanceolate through oval to elliptic and elliptic-lanceolate, obtuse or acute; it is no uncommon thing to see all forms on a single individual; the serratures of the leaflets are more or less glandular-tipped in all the forms and in one variety they are somewhat glandular ciliate; the petiole and rachis vary from pubescent, with or without glands to glabrous or glandular; the prickles are usually slender, but in one variety they are frequently stouter and recurved. All forms intergrade one into another and are best treated as a single species. Dearborn, July 6, 1918, No. 5021a; Orion, July 7, 1918, No. 5044a; Bloomfield, Sept. 8, 1918, No. 5107.

R. Carolina var. GLANDULOSA (Crepin) n. comb. (*R parviflora* var. *glandulosa Crepin*, Bull, Soc. Bot. Belg. XV, 68, 1876 *R serrulata* Raf. Ann. Gen. Sci. Phys. V. 218, 1820.) Rachis usually glandular and some of the leaflets with some glandular ciliation. Parkedale, July 4, 1918, No. 5039; Orion, July 7. 1918, No. 5046a; Bloomfield, Sept. 8, No. 5115.

R. CAROLINA var. GRANDIFLORA (Baker) n. comb. (*R. humilis* var. *grandiflora Baker;* Willm. Gen. Rosa I, 207, 1911, and *R. obovata* Raf. according to Rydberg in N. A. Flora XXII, 499, 1918.) Leaves usually obovate and obtuse with a cuneate base. Perhaps the most distinct of the various forms. Keweenaw Co., Sept. 10, 1888, No. 694; Parkedale, July 4, 1918, No. 5036.

R. CAROLINA var. LUCIDA (Ehrh.) n. comb. (*R. Virginiana* Miller, Gard. Dict. No. 10, 1768; *R. humilis* var. *lucida* (Ehrh.) Best, Bull. Tor. Club XIV, 256, 1887). In this variety the prickles are usually stouter than in the others, and often reflexed or recurved. Parkedale, July 4, 1918, No. 5038; Orion. July 7, No. 5045a.

LEGUMINACEAE.

Lespedeza capitata Michx. var. *longifolia* (DC.) T. & G. Rochester, Oct. 5, 1913, No. 3538; Bloomfield, Sept. 8, 1918, No. 5108.

Lathyrus palustris L. var. *myrtifolius* (Muhl.) A. Gr. f. PALLIDA n. f. Flowers white or whitish. Open tamarack swamps. Orion, July 7, 1918, No. 5052.

SAPINDACEAE.

Aesculus glabra Willd. Bloomfield, Oakland Co., Mr. C. Billington, 1917; May 25, 1918, No. 4865.

ZIZIPHACEAE.

Rhamnus cathartica L. At some time or other a hedge was planted on a farm in the Bloomfield Hills region. The hedge or what is left of it, is still a score or so of yards in length, impenetrable, and about 20 feet in height. The region in the vicinity of the hedge is well covered with young plants, which goes to prove that it is spreading from seed and has become naturalized. Sept. 8, 1918, No. 5109.

TILIATACEAE.

Tilia Americana L. The leaves of the typical species are usually described as glabrous or nearly so. I have seen no Lindens in southern Michigan with glabrous leaves; a leaf here and there is quite densely pubescent with stellate hairs. Generally, however, the leaves are covered on the under side with a fine pubescence with a trace of stellate and long simple hairs. There are two well defined and easily recognized forms based on size and shape of leaves. The large leaved form at flowering time has the leaves 4 or 5 inches wide and 5 or 6 inches long, measured along the midvein, ovate to ovate-oblong, obliquely, truncate or obliquently cordate, style, peduncle and usually the bract glabrous, pedicles stellate pubescent but branches of the cyme glabrous. This probably is the *T. neglecta* Spach, Ann. Sci. Nat, II. 2, p. 140, t. 15, 1834, and may be known as *T. Americana* var. SCABRA n. var. Junior, July 13, 1918,

No. 5061. Widely distributed in southern Michigan. The small leaved form has leaves about ½ as large, about 1½ to 3 inches long and the same in width, round ovate and more generally obliquely cordate, style pubescent at base, peduncle glabrous but bract usually more or less stellate pubescent, pedicels stellate pubescent and cyme branches more or less so. This may be known as *T. Americana* var. SCABRA f. MICROPHYLLA. n. f. Frequent at Rochester and vicinity, July 13, 1918, No. 5062, and Oct. 28, 1917, No. 4803. Large leaves on succors may be over a foot in diameter.

CORNICULATACEAE.

Epilobium oliganthum Mx. (*E. lineare* var. *oliganthum* (Mx.) Trelease). The typical, low, simple, few-flowered form with opposite, linear leaves I have not seen in Michigan. The common form here is the common form of the species with linear, strongly revolute leaves, frequently revolute clear to the midvein, densely bushy-branched above, forming a compact top especially during the fruiting season. This is the *E. lineare* Muhl. Cat. 39, 1813; *E. rosmarinifolium* Pursh Fl. I, 259, 1814; *E. leptophyllum* Raf. and *E. densum* Raf. Desv, Jour. Bot. II, p. 271, 1814; *E. squamatum* Nutt. Gen. I, 250, 1818; *E. palustre* var. *albescens* Richards. Frankl. Journ. 12, 1823; *E. palustre* var. *albiflorum Lehm.* in Hook. Fl. Bor. Amer. I, 207, 1833; and *E. palustre* var. *lineare* A. Gr. Man., 130, 1856. It may be known as E. OLIGANTHUM var. ALBESCENS (Richards.) n . comb. In swamps near Bloomfield, Sept. 8, 1918, No. 5102. Another farm, somewhat taller, (about 2 feet high,) much more slender and divaricately branched forming a broad, open top has lanceolate flat leaves, (primary, 1½-2 lines wide) margin barely recurved and may be known as *Epilobium oliganthum* var. GRACILE n. var. Swamps near Bloomfield, Sept. 8, 1918, No. 5103.

UMBELLATACEAE.

Thaspium trifoliatum (L.) A. Gr. In *Rhodora* for March, 1918, Mr. S. F. Blake, in a discussion of this species and the Clayton Herbarium, makes the statement that Nuttall's *Thaspium aureum* is ultimately based upon the *Smyrnium aureum* L. and consequently Nuttall's name must be considered as a synonym of *Zizia aurea* (L.) Koch. In making this statement Mr. Blake is making Nuttall say what he never intended to say, what he never did say, and probably what he never thought of saying. The conclusion of Blake would be a legitimate one if Nuttall had proposed the species on synonyms alone, as, for instance, has been done in Vol. V of the Memoir of the Torrey Botanical Club for a large number of new combinations. But Nuttall gave a fairly accurate description of his species, so accurate, indeed, that it will tax the ingenuity of the most expertly critical of modern American botanists to discover any resemblance in the fruit of *T. aureum* as described by Nuttall to that of *Zizia*

aurea (L.) Koch or to reconcile the reduction of the former to the latter. *Thaspium* aureum Nutt. is exemplified by Nuttall's description, not by the synonym of Pursh listed after the description. Nuttall wrote an entirely new and accurate description based upon the species he had before him, not upon Pursh's description. That he quoted Pursh's *Smyrnium aureum* as a synonym of his own species is due to a mistaken identification and in no wise can separate Nuttall's name from his species which is a true Thaspium. Blake also claims that *Thapsia trifoliata* L. is the same as the purple flowered *Thaspium atropurpureum* Nutt. because the specimen in the Clayton herbarium is a purple flowered plant, the Linnaean species being based through the Gronovian reference on the Clayton specimen. The Gronovian description calls for a plant with crenate leaflets; those of *T. atropurpureum* Nutt. are serrate. The purple flowered species can not be typical *Thapsia trifoliata* L. because it does not answer to the description. Of the yellow-flowered species generally known as *Thaspium aureum* Nutt. there are two forms, one with serrate leaflets typical of Nuttall's species and one with crenate leaflets which is typical *T. trifoliatum* (L.) A. Gr. This latter is occasional in southern Michigan. A form with simply ternate stem leaves and cordate radical leaves has often been reported by some as *Zizia cordata* (Walt.) D. C. Rockwood, June 16, 1918, No. 4952; Ypsilanti, May 19, 1918, No. 4827½. The Ypsilanti plant has the radical leaves ternate and lower stem leaves biternate.

Thaspium trifoliatum var. *aureum* (Nutt.) Britt. This is the yellow-flowered form with serrate leaflets. Ypsilanti, May 19, 1918, No. 4827; Rochester, May 28, 1918, No. 4882b. The *Thaspium atropurpureum* Nutt. Gen. 1, 196, 1918, is but a simple flowered form of *T. aureum* Nutt. and may be known as *T. trifoliatum* var. *aureum* f. *atropurpureum* (Desr.) n. f. I have not seen it from Michigan but it has been reported from various places in the southern section of the State.

Daucus Carota L. f. ROSEUS n. f. Flowers pale rose. River Rouge, July 21, 1916, No. 4339; Harris, July 13, 1918, No. 5078.

POLEMONIACEAE.

Phlox divaricata L. f. PURPUREA n. f. Flowers reddish purple. Redford, May 24, 1918, No. 4853; Ypsilanti, May 19, 1918, No. 4839.

P. divaricata L. f. ALBIFLORA n. f. Flowers white. Ypsilanti, May 19, 1918, No. 4838.

VERBENACEAE.

Verbena hastata L. var. *oblongifolia* Nutt. Briefly characterized as with the foliage and flowers of *V. hastata* L., but with the elongated loosely panicled spikes and scattered flowers of *V. urticaefolia* L. Franklin, Sept. 22, 1918, No. 5159, Billington, Farwell, and Gladewitz.

RINGENTACEAE.

VERONICASTRUM VIRGINICUM f. PURPUREUM n. f. (*Leptandra Virginiaca* var. *purpurea* Ph. in Eat & Wright N. Amer. Bot., 297, 1840). Bloomfield, Sept. 8, 1918, No. 5113.

V. Virginicum var. *lanceolatum* f. ROSEUM n. f. Flowers pink or rose colored. Parkedale, July 4, 1918, No. 5027, Billington and Farwell.

PLANTAGINACEAE.

Plantago media L. Cranbrook, 1918, Billington.

SCABIOSACEAE.

Dipsacus Fullonum L. (*D. sylvestris* Huds.) f. TERNATUS n. f. Leaves in threes. Detroit, June 29, 1918, No. 5003.

COMPOSITACEAE.

Aster laevis L. One of our commonest as well as one of the most elegant of asters and very variable. In the type, the plant is often 3 or 4 feet in height, with a loose, open, oblong panicle that is often more than ½ the length of the plant. Stem leaves clasping by an auriculate base, the lowermost tapering into a winged petiole, the others sessile; the median lanceolate, often 4 or 5 inches long by 1 inch wide, the small subulate leaves of the branches and branchlets strongly auriculate and abruptly contracted above the auricles, thence tapering into an accumination. Near Rochester, Oct. 10, 1918, No. 5205.

Aster laevis var. *laevigatus* (Hooker) A. Gr. Somewhat similar, stem leave often broadly lanceolate (1½-2 inches wide) and thinner, the small leaves of the branches and branchlets subcordate and oblong-lanceolate, not contracted above the base but usually nearly uniform in width for most of their lengths; panicle often shorter and more ovate. Oxford, Oct. 11, 1917, No. 4721a; Rochester, Oct. 10, 1918, No. 5207.

Aster laevis var. FALCATUS n. var. Panicle usually shorter and ovate; median stem leaves usually broadest at the auriculate base, linear—or oblong—lanceloate, under ¾ inch wide and often 6 inches long, some of them falcate; small subulate leaves as in the preceding variety. Rochester, Oct. 10, 1918, No. 5206.

Aster laevis var. PANDURATUS n. var. Panicle and subulate leaves as in the preceding varieties. Median stem leaves small, 2 or 3 inches long by ½ to 1 inch wide, ovate or oblong usually pandurate. Rochester, Oct. 10, 1918, No. 5008.

Aster laevis var. *amplifolius* Porter. A not unusual form with the leaves broadly ovate. Rochester, Oct. 10, 1918, No. 5209.

Aster laevis var. THYRSOIDEUS n. var. Similar to the var. *falcatus*, but the inflorescence reduced to a thyrse often a foot or more long. Rochester, Oct. 10, 1918, No. 5209½.

Xanthium glanduliferum Greene. The yellow burrs give it a peculiar appearance at once distinguishing it from the other species. Oakwood, Sept. 15, 1918, No. 5118; River Rouge, Sept. 15, 1918, No. 5139.

Helianthus petolaris Nutt. Scarce. Oakdood, Sept. 15, 1918. No. 5121.

Artemisia gnaphalodes Nutt. Harris. July 13, 1912, No. 5082, Billington & Farwell.

Erechtites hieracifolia var. *prealta* (Raf.) Fernald. Occasional. Detroit, Sept. 20, 1918, No. 5153½.

Senecio obovatus var. *rotundus* Britton. Huron River valley at Ypsilanti, May 19, 1918, No. 4828.

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METEOROLOGICAL DATA, DOUGLAS LAKE MICHIGAN, 1912-1918.

BY FRANK C. GATES AND RUTH E. HURD.

In order to place the meteorological data of the Douglas Lake region where it can be more available, the following tables were prepared by Ruth E. Hurd and F. C. Gates for presentation at the 1919 meeting of the Michigan Academy of Science and for publication in its annual report:

Location: Douglas Lake is located in Cheboygan County, Michigan, in the extreme upper part of the Lower Peninsula, about equidistant from Charlevoix, Mackinac City and Cheboygan. The Biological Station of the University of Michigan is located along the Southeastern shore of Douglas Lake.

Instrumentation: Weather instruments were maintained in the immediate vicinity of the Log Laboratory just back from the shore of Douglas Lake. Readings of each instrument were taken twice daily, during the summer session, at 7 A. M. and 7 P. M., Eastern Time, and recorded on forms which are filed in the station archives.

Temperature: The temperature readings were obtained from a Sixe Thermometer exposed under the open aquarium shed. The readings give the day and night maximum and minimum temperatures. With a few exceptions the same readings also give the 24-hour, midnight to midnight, maxima and minima. In these exceptions the midnight reading was obtained directly when it was evident that such a reading would be necessary, or calculated from a late night and an early morning reading by assuming a uniform rise or fall in temperature between such readings. Such would be the case not more than three or four times during the summer. The tables here following are expressed on the basis of midnight to midnight temperatures. Should the work of an investigator necessitate the separation of the night period from the day period, he is referred to the records on file at the Biological Station and in duplicate at Ann Arbor, Michigan.

Precipitation: Rainfall records were obtained by the use of a funnel rain gauge and expressed in inches and hundredths.

Pressure: Barométric readings were recorded at the station and are on file but are not included in this report.

Evaporation: Since 1915, records of evaporation have been obtained in connection with atomometer studies on various features of the vegetation, but have not been worked up for inclusion in this report.

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Wind: Records of wind direction and velocity are not kept at present. Such records can in general be interpolated from the records of the Weather Bureau stations at Cheboygan, Charlevoix and St. Ignace, Mich, about 17 to 20 miles northeast, southwest and north respectively. The records from Douglas Lake approach most nearly those of Cheboygan.

Water Level: Records of the water level of Douglas Lake are kept by the Engineering Camp on Douglas Lake, but have not been worked up for this report.

Summary and Conclusions: As the purpose of this paper is merely to make the meteorological data more available, no attempt will be made to summarize the weather of the Douglas Lake region further than to call attention to certain outstanding features of the summers.

The weather conditions during the summer sessions are as a rule comfortable and conducive to active work. The average weekly temperature varies from 67.6° during the first week to a maximum of 71.0° during the fourth week, following which it drops gradually, reaching an average of 66.7° during the last week of the session. Periods of very hot weather are unusual. In only two out of seven years of records has a temperature of 100° or more been reached three times in 1916 and twice in 1917. The night temperatures are always satisfactory, in seven years a minimum of 70° or above having occurred but sixteen times, eight of which were in 1916—a memorably hot summer throuout the middle west. But twice has the thermometer remained above 80° during the night and that on consecutive nights at the culmination of the severe hot wave late in July, 1917, during which 104°, the maximum recorded temperature, also occurred.

With the exception of the sixth week of the summer session, the rainfall is moderate and rather scattering, averaging about .40 inches per week (.26 to .49). In the sixth week, however, the second week following the maximum average temperature, there have been heavy rain storms during five out of seven summers, making the average rainfall of that week 1.72, more than four times as great as the average for any other week. In 1913, the heaviest precipitation occurred during the fifth week.

The growing season is short, as frosts in June and September are of normal occurrence. Once, in the seven years of record, frost occurred in August.

That the meteorological conditions are highly favorable and stimulating for the field work of which this station makes a specialty can easily be seen from these records.

TABLE No. 1

Maximum and Minimum Temperatures, Douglas Lake, Michigan

	1912 MX	1912 MN	1913 MX	1913 MN	1914 MX	1914 MN	1915 MX	1915 MN	1916 MX	1916 MN	1917 MX	1917 MN	1918 MX	1918 MN
June 20	...	..	..	..	70	43	..	..	.....	..	...	....	..	....
" 21	..	..	..	..	59	49	..	..	.....	..	62	(54)	..	....
" 22	..	..	..	..	62	54	..	..	.....	..	56	46	..	....
" 23	..	..	..	..	75	54	..	..	.....	..	60	46	..	....
" 24	..	..	..	..	87	54	..	..	.....	..	66	52	..	....
" 25	..	..	..	..	76	59	..	..	.....	..	70	44	..	....
" 26	..	..	..	..	78	50	..	..	.....	..	68	63	..	....
" 27	..	..	..	..	71	54	92	..	.....	..	66	58	..	....
" 28	..	..	..	..	64	48	91	52	.....	..	82	50	..	....
" 29	..	..	..	..	72	45	87	56	.....	..	70	56	..	....
" 30	..	..	..	..	81	..	83	58	.....	..	85	50	58	(56)
July 1	..	..	..	..	63	57	83	55	82	51	82	62	58	47
" 2	..	..	80	..	76	52	78	57	74	61	64	52	70	39
" 3	86	..	90	47	81	48	74	48	78	58	64	54	78	48
" 4	86	65	81	69	79	60	69	50	85	56	74	50	85	57
" 5	86	61	85	66	91	52	56	51	91	52	71	50	86	62
" 6	95	66	66	52	94	54	76	44	89	55	82	60	63	51
" 7	88	64	74	55	78	58	68	51	88	63	78	56	68	49
" 8	88	66	80	53	75	59	80	49	71	58	84	64	72	51
" 9	86	69	70	63	86	52	86	49	78	49	74	60	70	55
" 10	77	67	68	52	90	55	92	54	89	44	64	54	73	57
" 11	76	58	82	42	82	64	78	54	91	57	64	54	70	52
" 12	88	56	69	54	83	62	77	62	87	62	74	54	79	55
" 13	80	70	62	54	76	63	82	59	86	67	76	56	80	52
" 14	92	54	74	46	86	60	85	64	86	55	76	50	80	51
" 15	70	57	78	51	92	60	75	64	98	56	74	60	78	55
" 16	76	46	87	63	92	68	76	64	85	66	84	56	72	64
" 17	78	45	77	59	78	68	82	61	84	68	78	58	73	54
" 18	65	47	70	67	67	57	70	57	96	61	76	64	83	44
" 19	70	46	78	65	78	46	70	55	100	70	84	56	86	52
" 20	74	48	72	57	83	49	76	55	84	72	82	62	92	63
" 21	77	58	79	49	90	54	76	49	87	54	90	62	97	68
" 22	74	54	85	59	94	62	78	47	86	62	94	64	98	64
" 23	71	60	75	62	77	68	84	48	90	67	82	66	87	66
" 24	64	60	69	58	79	65	66	55	85	62	92	62	90	61
" 25	70	59	79	45	86	56	75	52	92	63	98	66	90	67
" 26	73	60	88	49	87	63	81	56	86	67	90	67	92	66
" 27	78	49	92	67	77	67	82	50	75	67	82	60	81	63
" 28	79	64	84	63	74	59	74	61	99.4	67	90	58	87	51
" 29	72	57	86	52	78	53	88	52	100.3	72	101	80	72	55
" 30	68	52	93	58	87	52	86	55	102	73	93	82	70	52
" 31	64	51	82	68	77	61	82	64	81	62	104	70	76	41
Aug. 1	69	50	74	58	78	56	79	58	83	55	86	72	86	46
" 2	61	51	86	57	73	59	65	57	88	50	76	60	70	55
" 3	61	52	74	64	75	50	58	56	86	65	70	56	68	42
" 4	68	53	78	54	83	46	64	56	90	62	86	48	87	53
" 5	75	51	82	50	90	54	65	56	85	71	80	66	82	59
" 6	76	44	77	63	83	62	66	57	99.2	58	72	60	88	60
" 7	75	56	86	66	81	50	68	58	86	72	78	43	77	65
" 8	69	59	82	65	91	51	71	58	78	66	67	59	67	58
" 9	66	61	84	64	98	64	76	58	85	56	67	53	68	60
" 10	73	61	72	61	78	63	83	56	81	58	74	52	88	60
" 11	74	57	71	46	72	54	80	56	74	70	82	52	80	59
" 12	75	61	73	52	79	50	79	58	70	60	82	54	87	52
" 13	84	58	88	54	76	53	72	59	68	56	72	62	88	71
" 14	70	51	89	63	71	58	83	58	74	45	76	58	75	60
" 15	60	47	97	65	73	58	84	58	82	56	84	56	77	55
" 16	70	41	86	70	82	54	77	62	83	57	74	62	80	48
" 17	57	49	91	65	83	58	67	50	88	55	70	55	77	51
" 18	67	54	85	64	83	64	71	49	89	65	78	56	75	44
" 19	66	54	73	62	75	60	74	48	97	68	80	64	82	43
" 20	68	57	85	51	76	61	80	49	96	71	70	64	90	48
" 21	72	58	89	67	..	62	..	50	96	68	78	53	84	66
" 22	66	61	..	..	..	..	..	..	76	60	83	52	82	60
" 23	57	52	..	..	..	..	..	..	78	55	78	60	..	70
" 24	..	..	..	..	..	..	..	..	74	61	66	50	..	....
" 25	..	..	..	..	..	..	..	..	68	49	...	47	..	....
" 26	..	..	..	..	..	..	..	..	66	54	...	..	..	....
" 27	..	..	..	..	..	..	..	..	.....	42	...	..	..	....

(Note.—The maxima and minima are for the 24 hours from midnight to midnight.)

Observers:
1912—H. A. Gleason
1913—Ada K. Dietz
1914—Ada K. Dietz
1915—F. C. Gates
1916—F. C. Gates
1917—E. L. Lambert
1918—F. C. Gates

TABLE No. 2

(For 24 hours ending 7 p. m.)

	1912	1913	1914	1915	1916	1917	1918
June 27	....	....	....	—	....	—	....
" 28	....	....	....	—	....	—	....
" 29	....	....	....	—	....	0.08	....
" 30	....	....	—	—	....	—	1.10
July 1	....	....	—	—	—	0.56	0.34
" 2	....	—	—	0.02	0.01	0.02	0.09
" 3	tr	—	—	—	—	0.06	—
" 4	0.05	0.64	—	0.64	—	—	—
" 5	—	0.07	—	0.02	—	—	0.01
" 6	tr	—	—	—	—	—	—
" 7	—	—	0.03	—	0.13	—	—
" 8	—	—	—	—	tr	—	—
" 9	0.39	—	—	—	—	—	tr
" 10	0.06	—	—	—	—	0.08	tr
" 11	—	—	—	0.05	—	0.03	0.23
" 12	—	0.73	0.33	0.12	—	0.03	—
" 13	tr	0.06	—	—	—	—	—
" 14	—	—	—	0.21	—	—	—
" 15	0.15	—	—	0.04	—	0.02	tr
" 16	—	0.02	—	0.09	0.09	—	0.06
" 17	—	tr	—	0.01	—	0.01	—
" 18	0.01	—	0.02	tr	—	0.01	tr
" 19	—	0.03	—	0.02	—	—	—
" 20	—	tr	—	—	—	0.51	tr
" 21	—	—	—	tr	—	—	—
" 22	—	—	—	—	—	—	—
" 23	0.06	0.60	0.82	—	—	—	tr
" 24	0.31	0.05	tr	0.20	—	—	—
" 25	0 01	—	—	0.01	—	—	0.55
" 26	—	—	0.18	—	0.01	—	tr
" 27	—	0.02	0.34	—	0.83	—	—
" 28	0.02	—	0.12	0.26	—	—	—
" 29	—	—	—	—	—	—	0.11
" 30	—	—	—	—	—	—	—
" 31	—	0.85	—	—	—	—	tr
Aug. 1	—	0.46	—	tr	—	—	—
" 2	0.25	—	0.01	0.41	—	—	—
" 3	—	0.02	—	1.97	—	—	tr
" 4	—	—	—	0.17	—	—	—
" 5	—	—	—	0.54	—	tr	—
" 6	0.02	—	—	0.04	—	—	0.54
" 7	2.20	—	—	0.12	0.61	0.50	0.02
" 8	0.05	0.03	—	tr	0.13	0.02	1.00
" 9	0.99	—	0.44	tr	—	0.44	0.05
" 10	2.07	—	0.08	—	tr	—	—
" 11	0.14	—	—	—	0.08	—	0.36
" 12	—	tr	0.03	—	tr	0.23	—
" 13	—	—	0.05	0.51	—	0.06	0.15
" 14	—	tr	—	tr	—	—	0.04
" 15	—	—	—	—	—	—	—
" 16	—	—	0.16	tr	—	—	—
" 17	0.96	—	—	—	—	—	—
" 18	0.01	—	0.03	—	0.18	—	—
" 19	—	—	—	—	—	0.14	—
" 20	0.07	—	0.91	—	—	—	—
" 21	0.03	—	—	—	—	—	—
" 22	—	....	....	....	—	—	0.36
" 23	—	....	....	....	—	0.58	....
" 24	....	....	....	....	0.37	0.03	....
" 25	....	....	....	....	0.08	0.14	....
" 26	....	....	....	....	0.21	....	....
" 27	....	....	....	....	—	....	....

TABLE No. 3

Weather Summaries, Douglas Lake, Michigan

(°F, precipitation in inches)

	Temperature					Precipitation	
	Abs. Max.	Aver. Max.	Abs. Min.	Aver Min.	Mean	Ppt.	Days Ppt.
July, 1912	95	77.6	45	57.5	67.7	1.06	9
August, 1912	84	68.7	41	53.8	61.2	6.79	11
July, 1913	93	78.5	42	56.7	67.8	3.07	10
August, 1913	97	82.0	46	60.1	71.0	0.51	3
July, 1914	94	81.8	46	58.2	70.0	1.84	7
August, 1914	98	80.0	46	56.5	68.0	1.71	8
July, 1915	92	77.6	44	54.6	66.1	1.69	13
August, 1915	84	73.1	48	55.6	64.1	3.76	7
July, 1916	102	87.3	44	61.2	74.2	1.07	5
August, 1916	99	82.3	42	59.4	70.7	1.66	7
July, 1917	104	81.3	50	60.3	70.9	1.33	10
August, 1917	86	76.2	43	56.6	66.2	2.14	9
July, 1918	98	79.2	39	55.2	67.2	1.39	7
August, 1918	90	79.9	42	55.9	67.6	2.52	8
July	104	80.5	39	57.7	69.2	1.64	9
August	99	77.5	41	56.9	67.0	2.73	8

TABLE No. 4

Table showing Average Maxima by weekly periods, (degrees F.)

	1912	1913	1914	1915	1916	1917	1918
0	....	....	73	....	....	72	....
1	88	84	74	84	82	74	71
2	83	73	85	75	88	73	73
3	75	75	82	79	89	81	81
4	72	78	84	74	90	90	91
5	68	85	80	81	88	88	76
6	72	80	82	66	82	74	80
7	70	82	78	78	83	77	81
8	66	85	80	76	79	76	83

TABLE No. 5

Table showing Average Minima by weekly periods, (degrees F.)

	1912	1913	1914	1915	1916	1917	1918
0	....	....	53	....	....	53	....
1	64	61	52	54	58	55	51
2	64	53	56	50	56	56	53
3	49	58	63	61	65	60	55
4	57	54	57	52	66	63	65
5	54	60	59	56	63	67	49
6	55	61	53	57	63	55	59
7	52	59	57	58	57	58	57
8	56	62	60	52	60	56	55

TABLE No. 6

Table showing Average Means by weekly periods, (degrees F.)

	1912	1913	1914	1915	1916	1917	1918	Average
0.............	....	....	63	....	....	63	....	....
1.............	78	74	64	70	70	64	61	67.6
2.............	74	63	71	63	72	65	63	67.0
3.............	62	67	72	70	77	70	68	69.4
4.............	65	66	71	63	78	77	78	71.0
5.............	61	73	69	68	75	77	62	69.4
6.............	63	71	68	62	72	65	69	67.1
7.............	61	71	68	68	70	67	69	67.5
8.............	61	73	69	63	69	65	68	66.7

TABLE No. 7

Table showing Precipitation by weeks, (inches)

	1912	1913	1914	1915	1916	1917	1918	Average
1.............	.05	.71	0	.02	.14	.64	1.54	.44
2.............	.45	.73	.03	.66	0	.14	.23	.32
3.............	.16	.11	.35	.52	.09	.55	.06	.26
4.............	.38	.65	.82	.22	.84	0	.55	.49
5.............	.27	1.33	.64	.27	0	0	.11	.37
6.............	5.33	.05	.01	3.25	.82	.96	1.61	1.72
7.............	1.10	tr	.60	.51	.18	.29	.55	.46
8.............	.11	0	1.10	tr	.66	.89	.36	.45